# WATER UTILITY DIRECT AVOIDED COSTS FROM WATER USE EFFICIENCY

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**The California Urban Water Conservation Council**

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Any errors that remain are the sole responsibility of the project team.

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# CHAPTER 1: DIRECT WATER UTILITY AVOIDED COSTS FROM WATER USE EFFICIENCY

## INTRODUCTION: WHY DO WATER USE EFFICIENCY?

Water utilities are facing intense challenges they never before faced:

- Substantial need for investment to replace or upgrade an aging infrastructure.
- Increasing competition for raw water sources.
- Threats to existing watersheds and surface waters.
- Lingering unresolved issues with potentially over-drafted groundwater basins.
- The emergence of new threats to water quality and safety.
- Changing environmental compliance and public-health standards.
- Dependency on complex power-supply networks and markets.
- Natural and human-caused threats to safety and security.
- Higher expectations from customers for communication and service.
- Pressure from all stakeholders for more public involvement.

Without exception, each of these challenges presents water utilities with additional costs associated with providing water service. The potential financial outlays by water and wastewater utilities are substantial and water prices are likely to continue to outpace the rate of inflation (Beecher). The water industry means can be rightly characterized as a "rising-cost" industry—the future cost of water service will be greater than its historical cost. These costs include source-of-supply costs, transmission and distribution costs, and treatment costs. Costs are rising for most types of water systems. For older systems, infrastructure replacement is a key cost driver. Water supply is highly energy intensive, so rising energy costs are a factor. Although per-capita demand for water is relatively flat, aggregate demand is driven by population growth. Systems that serve growth areas often have the added pressure of developing expensive new sources of supply, including costs associated with water purchasing and transmission.

Other forces also are affecting the water industry. The combined effect of water and wastewater makes matters more difficult for both providers. Both are under competitive pressure, including institutional competition (public v. private). Both public and private systems face competitive pressure in the capital markets. Public systems face additional political pressures as well, including resistance to raising rates. Systems of all types are expected to operate more efficiently to help keep costs down. The environment within which they operate, including the regulatory environment, is increasingly uncertain.

Still, for most of these challenges, alternatives are available. The key question is how a utility can choose, particularly in the context of uncertainty and imperfect information. Integrated water management, with its emphasis on considering a broad spectrum of options and applying systematic evaluation tools to the selection process, may offer some guidance.

Developing a portfolio of options is at the heart of integrated resources planning (IRP). One of the tenets of IRP is finding solutions that achieve goals at the least cost. But broadening the definition of the resource planning problem in the search of efficiency alternatives helps deepen the understanding of "integrated" planning.

Integrated planning is particularly useful in the joint contemplation of supply-side and demand-side options in developing the resource portfolio. Water utilities that once viewed themselves as being only in the water supply business, have redefined their mission as one of providing *safe* and *reliable* water service. This redefinition immediately admits of new objectives beyond supplying water quantity—safety and reliability implies that water quality and delivery certainty are also objectives within the mission of water utilities. Cost pressures may not come directly from the water supply side; the impetus for several large scale water efficiency programs has come about from constraints on existing wastewater system.

## HOW WATER EFFICIENCY HELPS

Water utilities have increasingly come to appreciate the value of water use efficiency (WUE) for accomplishing their long-term mission of providing a safe and reliable potable water supply. The importance of water efficiency goes well beyond the short-term measures invoked to respond to drought emergencies, and is much broader in scope. Improved water-use efficiency is seen as a viable complement to – and in some instances, a substitute for – investments in long-term water supplies and infrastructure.

This understanding of water efficiency includes outdoor as well as indoor WUE, nonresidential water customers as well as residential customers, and utility delivery efficiency as well as end use efficiency. At the heart of the new understanding of water efficiency is an economic standard: a good WUE program produces a level of benefits that exceed the costs required to undertake the program. WUE programs for which this is not the case are questionable undertakings for water utilities. One of the key challenges lies in the determination of utility benefits from WUE programs. This report addresses this issue of quantifying water utility WUE benefits through avoided cost analysis. The question of how to avoid future cost lies at the heart of avoided cost analysis. By analyzing the direct costs that utilities can avoid via demand reduction, water utilities define the benefits produced by conservation programs.

- **Conceptual**. How do we define the benefits of conservation programs?
- **Analytical**. How should the benefit information be properly compared to make the correct decisions? What analytical tools can facilitate these comparisons?
- **Informational**. From where is a water utility to obtain valid and reliable information to estimate the benefit components?

## ORGANIZATION OF THE REPORT

This report is organized as follows:

- **Concepts**
    - Chapter 2 provides a general discussion of the definition of WUE benefits as the avoidable costs in a water utilities expansion path.
    - Chapter 3 provides a specific method of enacting water utility avoided cost estimation. This method is embedded in a user-friendly spreadsheet planning tool for avoided cost estimation. The model is described here; a detailed users guide is presented in Appendix A
    - Chapter 4 provides deals with Data Sources for estimating Direct Utility Costs, which fall into categories.
- **Tools**
  **A Water Utility Direct Avoided Cost Estimation Model –** This spreadsheet planning tool assists water utilities in developing robust and defensible avoided

cost estimates. By analyzing the direct costs that utilities can avoid via demand reduction, water utilities define the benefits produced by WUE programs. Influenced by system simulation models, this path-breaking work distinguishes between short-run and long-run costs and permits utilities to consider seasonal differences in avoided costs. This model is intended to inform the design of more valuable WUE programs.

- **Information**
  - Appendix A provides Instructions for use.
  - Appendix B provides illustrated examples of the Avoided Cost Estimation Model
  - Appendix C provides a list of Frequently Asked Questions (FAQ).

## CAUTIONS TO THE READER

1. These chapters presume an understanding of the different perspectives used by the CUWCC MOU and examines methodological issues of avoided costs from a water utility perspective. There is a companion project that addresses environmental effects not captured by a water utility perspective.
2. Chapter 2 provides the methodological review of concepts and theory. Chapter 3 provides the proposed method. In this way the conceptual issues of methodological approach are separated from the practical questions of how the method should be enacted.
3. The method proposed in Chapter 3 is inspired by the authors' experience with system simulation models. The proposed method adheres to the logic used by these models, while attempting to minimize data requirements. *Specifically*, the method allows utilities to estimate avoided costs that differ by season and, possibly, area. We have attempted to follow a variant of the KISS principle—Keep It Simple, not Stupid.
4. We remain open to feedback from users. Chapter 4 lays out the data requirements of the implementing model. The model provided can be demanding but accurate estimates of direct utility avoided costs require good information as inputs.

# CHAPTER 2: UTILITY AVOIDED COSTS METHODOLOGY—CONCEPTS AND THEORY

Water utilities who confront sudden changes in their cost structure have naturally turned to the question of how they can reduce the incidence of future costs. The question of how to avoid future cost lies at the heart of avoided cost analysis. By analyzing the direct costs that utilities can avoid via demand reduction, water utilities define a critical benefit produced by conservation programs.

In this chapter we explain the methodological background required to implement an analysis of utility avoided costs. Many avoided cost analyses focus solely on quantifying the value, in avoided costs, of overall reductions in demand (average system load.) This type of simplistic approach can lead to incorrect conclusions about the desirability of different kinds of conservation programs.

This chapter is divided into several distinct sections. The following section defines some basic concepts used in cost analysis. This is followed by a basic definition of avoided costs and a brief explanation of its applications in utility cost analysis. The following section separates avoided costs by time—short run avoided costs and long run avoided costs. This is followed by explanations of some methodologies that have been used in a water utility setting to quantify the avoided costs. The reader should note that these methods focus on quantifying the avoided cost of reductions in average demand load.

## COST CONCEPTS

Understanding the costing methods required to estimate a utility's avoided costs involves several basic issues. First, the distinction between **fixed and variable costs,** which is key to many costing methods, depends entirely on the time period under consideration. Second, assigning cost responsibility requires a distinction between **assignable and joint costs**. Third, **data** quality and availability will limit cost analysis. Fourth, **accounting costs** in a water utility's financial books can differ from **resource costs**—the total resource costs that include costs and benefits external to the water utility.  This section defines these basic cost concepts and explains their relevance to costing methods.

**Fixed versus Variable Costs:** Many costing methods identify costs of water service as either **fixed** or **variable** based on accounting expenditures. **Fixed** costs are expenditures that remain the same, regardless of the volume of water produced. Because large up-front capital costs are required to build capacity for meeting demand, some traditional costing methods classify all system expansion costs as fixed and refer to these costs as "demand" costs. **Variable** costs, also called "commodity costs," are expenditures that vary directly with the volume of water produced or consumed; variable costs include, for example, purchased-water, electrical, and chemical costs. Marginal costing methods recognize that the dividing line between fixed and variable depends on the period of time used for the analysis. In the long run, fixed capital expenditures can and do change, thus becoming "avoidable."

**Assignable versus Joint Costs:** If all costs could be easily, accurately, and cheaply assigned to specific utility functions, cost-causation would be straightforward. Some costs of water supply are considered "*joint*" costs because they reflect joint functions. As an example, providing flow capacity sufficient for fire protection *simultaneously* (or jointly) provides capacity that can be used for any other instantaneous high-flow use. Similarly, providing capacity for peak periods will necessarily provide capacity for nonpeak periods. Joint costs complicate the task of cost analysis**.**

**Data Issues**: Costing methods use, and are limited by, accounting data generated in the day-to-day operations of the water utility. The quality and availability of these data also affect the accuracy and applicability of avoided-cost methods. Much of the water supplier cost accounting data, for example, is not allocated by utility function—supply, storage, treatment, and conveyance. By improving the process of defining and collecting accounting-cost measures, better decisions can be made using even simple methods.

**Accounting costs differ from resource costs -** Accounting data used to estimate costs produce estimates that differ from the economic costs of providing water service for several reasons. Monkur and Fok (1993) assert that accounting costs **underestimate** economic costs due to:

- The use of historical depreciated costs instead of current replacement costs when allocating capital expenses.
- The exclusion of the opportunity cost of retained earnings and system development charges in the rate base.
- A valuation of water *in situ* (scarcity value) exactly equal to zero.

In effect, generally accepted accounting practices can produce cost estimates that are lower than the economic cost of water service.

## DEFINITION AND HISTORY OF AVOIDED COST METHODS

An important starting point in the discussion of using avoided cost methods to value conserved water is the proper definition of marginal costs. "Marginal" costs refer to the cost of producing (or not producing) another unit of water supply. Costs of an increment of supply are often referred to as "incremental" costs. In estimating marginal costs, a central issue is where the next increment of supply will come from and what it will cost. A variety of supply options with different capacity and cost consequences may be available. The identification and quantification of future resource alternatives lies at the heart of water agency planning. Existing water supply/management plans are a good place to start to determine baseline assumptions about the current set of resource alternatives to which an agency is committed.

**The Appropriate Time Horizon:** Calculating marginal cost involves projecting capacity costs, operating costs, and water demand over a specified time horizon. These projections may require data on the price elasticity of demand, anticipated changes in technology, and the prices of inputs required to provide water service.

Selecting the time horizon directly affects the estimation of marginal capacity cost (long-run marginal cost) and the marginal operating cost (short-run marginal cost). The length of the time horizon or planning period affects both the cost numerator and the output denominator in calculating marginal cost.

Sometimes a shorter time period has been chosen out of a misplaced desire for precision in estimating marginal costs. Though it is often true that shorter time horizons lend themselves to more precise cost and demand forecasts, **precision should not be confused with accuracy.** Forecasts over long time horizons may contain fewer known and more estimated quantities. These longer term forecasts can be more accurate, because they contain a broader set of alternatives, while necessarily being less precise. The choice of the time horizon also must take into account the span of time required to implement cost-effective changes in the mix, capacity or availability of resources. Most water agencies define a “time horizon” for planning purposes; this is a good working assumption until a longer or shorter horizon can be justified by analytic considerations.

Avoided cost methods have a long history of development in the economic literature and have been successfully applied to problems of public utility planning.[1] The historical evolution of traditional costing in the water industry drew heavily from methods developed for other public utility industries. In the energy and telecommunications industries, where most utilities are subject to economic regulation, average-cost pricing prevailed until roughly the 1980s. Marginal-cost methods have gained some acceptance in the realm of public utility regulation. In fact, the Public Utility Regulatory Policies Act (PURPA) of 1979 required the larger electric and gas utilities to consider these marginal costing methods.

The concept of marginal costs has also been extended beyond direct production costs. They should be thought of as inclusive of all marginal opportunity costs, including marginal connection costs and marginal environmental costs.[2]

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[1] In fact, some of the early work on marginal cost methods for public utilities was focused specifically on hydroelectric reservoirs. See Massé, P. 1944, *Application des probabilités en chaîne à l'hydrologie statistique et au jeu des réservoirs.* Paris. or Boiteux, M., 1949, “La tarification des demandes en pointe,” *Revue Générale de l'Electricité,* 58, 321-40.

[2] See for example, R.C. Griffin, 2001, “Effective Water Pricing,” *Journal of the American Water Resources Association.*

## MARGINAL COSTS—TWO COMPONENTS

Two important components of marginal cost are the change in operating costs caused by a change in the use of existing capacity (short-run marginal operating cost), and the cost of expanding capacity (long-run marginal capacity cost).

- Short-run marginal operating costs reflect the cost consequences during time periods in which some inputs are fixed. Short-run marginal costs are comprised mostly of variable operating costs
- Long-run marginal capacity costs extend to time periods far enough into the future to be changed by system and resources planning. Long-run marginal costing methods can identify costs that can be avoided through more efficient use or nonuse (conservation). Because the long-run concept of marginal costs (1) extends into the future, and (2) reflect all future alternatives, estimation methods must deal with more uncertainty.

### Marginal Operating Cost

A water agency's marginal operating cost (MOC) in any time period is a function of the system components whose operation would be cut back in response to a small reduction in that period's demand. These components are said to be operating 'on the margin'. In real time, the precise supplies, reservoirs, and treatment and conveyance facilities that would be cut back may be determined by a complex mix of economic, operational, regulatory, and other factors. The key is then to estimate the likelihood of each component being on the margin in each time period.

The literature includes many methods to estimate a water agency's marginal operating cost (MOC). Following are brief discussions of two of these.

### A Simple Method:

One technique used to calculate MOC is to forecast the annual operating expenses for the first year that a capacity increment is anticipated to become operational, and then divide that annual cost estimate by the forecast revenue-producing output for the same year

(Hanke, 1981)[3]. When operating costs can be predictably forecast, this technique can be extended over multiple years. The forecast annual operating expenses over the entire planning period in which the capacity increment is anticipated to become operational are divided by the forecast revenue-producing output for the same time period (Hanke, 1978). Water systems exhibiting significant seasonal operating cost differences—due, for example, to purchased water prices, electrical power expenses, or higher summer demands forcing use of more expensive supplies—can adapt this technique to a seasonal basis[4].

**Illustration:** Table 2-1 illustrates the two calculations of average operating cost. The example assumes that a new treatment plant is operational in Year 1. The projected annual operating expenses and revenue-producing output of a new facility are provided in the table. The first method, using data only from Year 1, generates an average operating cost of $0.47 per CCF. The second method, using data from Years 1 through 5, generates an annual estimate of average operating cost that increases to $0.50 per CCF.

**Table 2-1. Calculation of Average Operating Cost - Hanke Method**

| Description | Year 1 | Year 2 | Year 3 | Year 4 |
|---|---|---|---|---|
| Operating Expense (millions of dollars) | $4.343 | $4.3760 | $4.4370 | $4.7150 |
| Revenue-Producing Water(CCF) | 9,288,311 | 9,330,170 | 9,372,302 | 9,414,711 |
| Average Operating Cost ($/CCF) | $0.468 | $0.469 | $0.473 | $0.501 |

The primary advantage of this technique is its low data requirements. The primary disadvantage is that, strictly speaking, this technique produces an estimate of average, not marginal operating cost. An estimate of marginal operating cost can be produced using additional data and readily available statistical methods.

**A Regression-based Method:** A recent study by Bishop and Weber (1996) used three years of monthly historical cost data to develop statistical estimates of marginal operating

[3]The revenue producing output is used as a way to adjust for losses in the water system. Since most water systems exhibit some level of losses, more than one gallon of water must be produced in order to deliver one gallon.

costs. This study allows comparison of average operating cost methods with methods that control for other factors. In models for seven water agencies, this study found total marginal operating costs to range from $0.05 to $0.20 per CCF. (An eighth agency purchased treated water at a marginal cost of $0.59 per CCF with an additional two cents required for electrical distribution costs.) Table 2-2 provides a comparison of the average versus marginal operating costs derived from the study. As can be seen, the regression-based estimates of marginal operating costs are less than the average operating costs.[5]

**Table 2-2. Average versus Marginal Operating Cost Estimates**

| Agency | Supply Source | Average Cost, Total O & M ($/CCF) | Marginal Cost, Total O & M ($/CCF) |
|---|---|---|---|
| East Bay MUD | Surface Water Only | | $0.167 |
| Houston | Surface Water & Groundwater | $0.257 | $0.200 |
| Massachusetts WRA | Surface Water Only | | $0.610 |
| Palm Beach County | Groundwater Only | $0.371 | $0.151 |
| Phoenix | Surface Water & Groundwater | $0.577 | $0.111 |
| Portland | Surface Water Only | | $0.046 |
| San Antonio | Groundwater Only | $0.474 | $0.072 |
| Virginia Beach | Purchased Water | $0.606 | $0.606 |
| Source: Adapted from Chapter 5, *Impacts of Demand Reduction on Water Utilities*, Bishop and Weber, AwwaRF, 1996. | | | |

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[4]Other MOC methods can be found in Table 4-1 of Beecher and Mann, 1991.

[5] Since a regression model can be specified to estimate an "average" operating cost, it is wrong to attribute the difference between the two estimates solely to method. The regression-based method yielded a lower estimate because the model was able to control for the other influences upon operating costs. A simple average, by contrast, forces all variation in operating costs to be explained (caused) by output. Consider the model:

$$MonthlyOperatingCost = a + b \bullet \mathrm{Re}\,venue\,\mathrm{Pr}\,oducingQuantity$$

Where *a* and *b* are the coefficients to be estimated. If the coefficient *a* is constrained to be zero, the above regression equation will produce an estimate of *b* equivalent to an average operating cost. If the fixed cost coefficient a is not constrained and takes on a positive value, the estimated coefficient *b* will necessarily be less than the average operating cost.

Water agencies interested in replicating this approach would collect a set of consistent time series on operating costs, production volume (adjusted for system loss), and other factors that can influence operating costs (turbidity levels or deterministic time trends, for example.) Interested readers should refer to the original study for additional details on model specification and estimation.

Analysts who are put off by what may seem as an intimidating methodology should consider a direct application of this approach. Regression-approaches seek to control for external factors that can change operating costs other than changes in volume. The same question can be put directly to operators in the field: "How would your (electrical, chemical, or other operating) budget change with specified changes in revenue-producing output volume?" Compilation of this directly assayed information should yield the same answers produced by a well controlled statistical study.

**Marginal Capacity Costs**

Most of the marginal capacity cost (MCC) estimation techniques used in water system cost analysis are variations of two basic MCC approaches: (1) the avoided cost due to system expansion deferral (a time shift) and (2) the Average Incremental Cost (AIC) used to estimate a change in capacity requirement (downsizing).[6]

A common thread running through the alternative approaches is that the MCC results are very sensitive to the specification of the cost numerator **and** the quantity denominator. The application of any long run marginal costing method requires analysts to address several future cost issues:

1) Projections of demand—consistent with system planning—are essential for determining both the denominator in the cost function and to identify demand levels that trigger the need for incremental capacity[7].

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[6]Additional discussion of techniques for calculating marginal capacity costs can be found in Beecher and Mann, Table 4-1.

2) Cost projections to determine the numerator (the forecast of costs over the capital project life).
3) Inflation and discount rates should be consistent with those used in the planning process of the water agency. Sensitivity analyses should be conducted allowing these key assumptions to vary.[8]

Depending upon the method employed, other information (such as the capacity service lives, planned operating characteristics, and costs of other alternatives such as water purchases or reclaimed water) may be required.

We begin the methodological review of capacity costing with a brief description and discussion of each of these MCC techniques.

Marginal Capacity Cost as a Deferred Cost: As explicated by Turvey[9], this approach expresses MCC as either the cost incurred by an acceleration in growth of demand, or as the cost avoided by a deceleration of demand. A plan for system expansion is taken as a given, and only the timing of that expansion is varied; plans for system expansion are not re-optimized, only rescheduled. The original Turvey method examined the savings associated with slowing down system expansion through conservation. The cost numerator was formed by the change in the present value of capacity expenditures by

[7]Table 2-3 from the CUWCC report *Setting Urban Water Rates for Efficiency and Conservation* (page 4) provides a useful layout of water system capacity determinants:

| **Facility** | **Design Determinant** |
|---|---|
| Major surface water impoundment | Water rights, topography, engineering constraints, annual demands |
| Transmission lines and pump stations | Treatment plant capacity |
| Treatment plants | Peak day demands |
| Distribution lines, distribution pump stations | Fire flows, peak day, peak hour demands |
| Distribution reservoirs | 2-3 days of average day demand |

[8]Guidelines on the use of discount and cost escalation rates can be found in the *CUWCC Guidelines to Conduct Cost-Effectiveness Analysis of BMP's for Urban Water Conservation, 1996,* Chapter 2.

moving the capacity increment forward into the future. The usage denominator was the annual change in demand that allowed the postponement of the capital facility. The original Turvey method focused on the change in cost associated with a postponement or acceleration of the construction period.

**Illustration of Turvey MCC Method:**

The following example illustrates the calculation of MCC under the Turvey method. Assume that the agency planned to construct a treatment facility in three years (Year 3). As a result of demand management and conservation programs, annual demand decreases by 1,000 CCF per day (838 acre-feet per year). This decrease in demand allows the construction of a treatment facility to be postponed for one year (from Year 3 to Year 4.) The treatment facility costs $17.0 million. Taking the agency's planning discount rate of four percent (at a real or inflation-adjusted level), the $17.0 million spent three years from today would have a present value of (PV = $17.0 million ÷ $(1+.04)^{3}$ =) $15.113 million. By comparison, an additional year's delay would yield a present value of (PV = $17.0 million ÷ $(1+.04)^{4}$ =) $14.532 million. The cost numerator is the difference in the present value of capital expenditures by delaying the capital project from year three to year four ($15.113 million - $14.53 million =) $0.581 million. (Methodical analysts might also include a small adjustment for the residual difference in scrap value, due to a finite facility project life.) Dividing the change in cost of $0.581 million by the change in annual demand produces a MCC of 1.59 $/CCF. This estimate added to the MOC for the new facility produces the estimated total long-run marginal cost estimate.

Clearly, the avoided capital cost calculated by the Turvey method applies directly to valuing the worth of conservation programs. Conservation programs directly attempt to affect the growth of expected water demand. This change to water demand, if quantified, constitutes the quantity denominator of the marginal capital costs estimate. The more difficult part of the task would then be calculating what capital costs could then be postponed or avoided.

Several notable characteristics of the original Turvey method (1976) are:

1) The method produces an annual (not seasonal), estimate of MCC that changes each year. (Marginal costs are the same in the peak and off peak season.)

[9] Turvey, R. (1976) "Analyzing the Marginal Cost of Water Supply," *Land Economics*, 52, 158-168, May 1976.

2) The size of the planned system expansion only enters into the cost numerator. The quantity denominator is strictly determined by the change in annual demand that allows the deferral. Both of these quantities are empirically difficult to estimate and are associated with considerable uncertainty. If the postponement period, in the above example, were expressed as a range from 0 to 2 years, then the MCC would vary between zero and 3.12 $/CCF.
3) The Turvey MCC gets larger as the system gets closer to its capacity limitations and is zero otherwise. Since water projects involve large discrete changes in system capacity, the resulting Turvey marginal cost estimates could be volatile.
4) The Turvey MCC focuses only on the next capacity increment, ignoring the cost consequences of subsequent increments.

Different variants of the Turvey approach have been proposed:

1) To produce a seasonal estimate of MCC, Hanke (1975) suggested categorizing cost data into facility costs designed to meet peak demands and system costs designed to meet average demands. Hanke (1981) implemented a seasonal variant of a Turvey avoided capital cost by disaggregating cost and consumption data into peak and off-peak periods.
2) Several applications have stressed quantifying the demand expected in the future and linking changes in this expected demand to the corresponding sizes of the deferrable facilities. (For an illustration, see Hanke, 1981). These variants of the Turvey approach will use the same numerator (the difference in the present value costs of two differently timed but otherwise identical system expansions) while substituting the planned usable facility capacity (that matches the avoided demand) into the denominator. The denominator is also adjusted downward to account for the effect of system loss; due to distribution leaks, more than one gallon must be produced to deliver one gallon of water.
3) Several variants of the Turvey method use an averaging of the marginal cost over several years for different rationales:
    - as the long run consistent strategy that results when an administrative feasibility constraint is included in an optimal planning framework (Dandy, 1984),
    - to produce a consistent price signal for long-term decision making (Boiteux, 1959), and
    - as a more appropriate tradeoff between short-run allocative efficiency (efficient use of existing capacity) and long-run resource efficiency(efficient capacity-sizing decisions) (Mann et al., 1980).

The original Turvey method (1976) is direct, relatively straightforward, and requires only data available in the existing water system plan. As such, it is easily interpretable as the direct cost of additional (or avoided) water use.  Though directly appropriate for assigning value to conservation (demand-side management), strict implementation of the original Turvey method has several shortcomings: it does not reflect the higher cost of using water during peak periods (without an additional seasonal allocation step), it becomes erratic when capacity increments are lumpy, and it does not look beyond the next capacity increment.  Other methods for calculating marginal capacity costs have also been proposed.

Marginal Capacity Cost as an Average Incremental Cost:  The Average Incremental Cost (AIC) approach for estimating MCC involves the annualization of incremental cost.  The AIC approach first involves calculating annualized capacity cost (*K*), which is defined as the annual payment, over the useful service life of the new capacity (*n*), required to recover both financing costs and the additional capacity costs:

$$K \equiv \frac{C \cdot i \cdot [1+i]^n}{[1+i]^n - 1}$$

where: $K$ = total annualized incremental capacity costs,
$C$ = total capital expenditure required,
$n$ = useful service life of the capacity increment, and
$i$ = appropriate financing (interest) rate.

*"K"* must be calculated for each system function (that is, source development, transmission, treatment, etc.) in which a capacity increment is planned, since service lives will vary across these functions.  "*K"* can be disaggregated into peak/off-peak components.

The output (quantity) denominator is based on the designed annual capacity (annual firm yield). The planned capacity, however, should be adjusted to account for losses due to leakage in the system. System losses mean that more than one gallon must be produced to deliver one gallon to the customer. For example, a system loss of 10 percent implies that 1.11 gallons must be produced for each gallon delivered. The output denominator can be expressed as revenue-producing annual capacity (annual planned delivery capacity averaged over the life of the plant)[10]

[10]Some AIC calculations take the accounting an additional step, separately accounting for the capacity that is used and the capacity that is held in reserve. Analysts should avoid using "expected capacity utilization" as the output denominator; this sends the exact wrong short run signal. (Since the expected utilization is low immediately after

**Illustration of Average Incremental Cost (AIC) MCC Method:**

Continuing the previous example, the AIC method can be used to estimate the marginal capital cost of the same new treatment facility. Assuming that the treatment plant has a useful service life of 25 years (n=25), and that the real annual interest rate is 4 percent (7 percent nominal financing rate and a 3 percent rate of inflation), the AIC method produces an annualized capacity cost (**K**) of $1,088,203. Dividing by the planned capacity of 10,000 CCF per day, the AIC method estimates the MCC of the treatment plant to be ($1,088,203 ÷10,000 CCF/day X 365 days =) 0.298 $/CCF. This AIC is then added to the MOC to yield the total marginal cost. Because the AIC method involves averaging, it's results are less sensitive to changes in the assumptions than other methods. A service life of 20 years produces an estimated AIC of 0.343 $/CCF and a real interest rate of 5.0 percent changes the estimated AIC to 0.330 $/CCF.

The example is simplistic because not all components of a treatment plant will have the same service life. More importantly, a treatment plant is of little use if an agency does not have a corresponding raw water source, pumping and transmission capacity to move the water, and storage facilities to handle fluctuations in system load.

A more realistic example of the AIC method for a major system expansion is illustrated in Table 2-4. Supply, treatment, pumping and storage capital improvements all are required for a major system expansion. Any costs related to expansion of the distribution system are considered customer costs and are not included in the AIC calculation. An analysis of each function determines the capital cost, useful physical life, and annual capacity cost. Annual capacity costs are summed by function and totaled. To derive the AIC estimate, the total annual capacity costs are divided by the output measure to arrive at a AIC per CCF. The summary at the bottom of Table 2-4 shows the effect of accounting for a 12 percent system loss by comparing marginal capital costs using the planned firm yield of the system expansion and the deliverable water (88 percent of the

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construction of a capacity increment and is high as the maximum capacity is approached, AIC with expected utilization in the denominator would send a high/low price signal when capacity is plentiful/scarce.) This handbook therefore recommends use of expected capacity utilization averaged over the life of the project, adjusted for system loss.

firm yield.) The AIC method produces an estimate of $ 1.91 per CCF for the system expansion.

**Table 2-4: Illustration of AIC Method for calculating the MCC of System Expansion.**

| Description | Total Capital Expenditure ( C ) | Life (n) | Annualized Incremental Capacity Cost ( K ) |
|---|---|---|---|
| Supply | | | |
| Wells | $15,000,000 | 40 | $757,852 |
| Reservoirs | $30,000,000 | 40 | $1,515,705 |
| Transmission Mains to Dist. System | $5,000,000 | 100 | $204,040 |
| Land | $18,500,000 | | $740,000 |
| Total Supply Capacity Cost | $68,500,000 | | $3,217,597 |
| Treatment | | | |
| Facilities | $10,000,000 | 25 | $640,120 |
| Equipment | $5,000,000 | 20 | $367,909 |
| Land | $2,000,000 | - | $80,000 |
| Total Treatment Capacity Cost | $17,000,000 | | $1,088,028 |
| Pumping | | | |
| Structures | $18,000,000 | 50 | $837,904 |
| Equipment | $5,750,000 | 20 | $423,095 |
| Total Pumping Capacity Cost | $23,750,000 | | $1,260,999 |
| Storage | | | |
| Facilities | $10,000,000 | 50 | $465,502 |
| Land | $2,500,000 | - | $100,000 |
| Total Storage Capacity Cost | $12,500,000 | | $565,502 |

| Summary | Annualized Capacity Costs (K) $ | Marginal Capacity Costs (K / Yield) $ per CCF | Marginal Capacity Costs (K / Delivery) $ per CCF |
|---|---|---|---|
| Supply Capacity Costs | $3,217,597 | $0.882 | $1.002 |
| Treatment Capacity Costs | $1,088,028 | $0.298 | $0.339 |
| Pumping Capacity Costs | $1,260,999 | $0.345 | $0.393 |
| Storage Capacity Costs | $565,502 | $0.155 | $0.176 |
| Total Capacity Costs | $6,132,126 | $1.680 | $1.909 |
| Increment to Supply (CCF/year), Planned Yield = 10,000 CCF/day * 365 days/year Delivery Capacity = Yield* (1-SystemLoss(12percent)) | | 3,650,000 | 3,212,000 |

The average costs for additional capacity increments can be used to calculate a downsizing avoided cost attributable to reduced demand. This relatively straight forward process involves comparing two average incremental capacity costs—the AIC designed without the effect of conservation programs and the AIC of a system designed with conservation. Though the calculation of avoided capacity costs due to downsizing is less common, it is mentioned here for several reasons. First, it is a valid method that has found use in the water industry. Second, these costing methods also provide the basis for the determination of a "good" price signal to be provided by water rates. Last, calculation of average incremental costs by function can serve as a useful benchmark for other costing methods.

## CONCLUSION

All of the foregoing approaches shed light on the issues that must be addressed in estimating marginal costs. However, none of them suffices as a method to be used by utilities given real-world resource and analytical constraints.

# CHAPTER 3: ESTIMATING DIRECT UTILITY AVOIDED COSTS

## INTRODUCTION

As described in Chapter 2, sound estimates of a water utility's direct avoided costs are critical to estimating the economic benefits of WUE to the utility. This chapter outlines the method that has been developed as part of this project to calculate such avoided cost estimates. This method forms the basis of an Excel-based modeling tool. The method and the model will be described in detail in Appendix A.

The estimation of a water utility's avoided supply costs begins with baseline assumptions about the future supply and infrastructure investments that would be made and the manner in which the system would be operated in the absence of conservation. The question that must then be answered is how one or both of these would change due to the demand reductions that occur as a result of conservation.

Variable operating costs (VOCs) are those costs which change as a function of the amount of water that is produced. These costs include such things as power and chemicals. Each system component (supply source, reservoir, treatment plant, transmission line, etc.) has its own VOCs, and the marginal operating cost is the expected reduction in such costs per unit of demand reduction. These are often called 'short-run avoided costs' and, as long as a conservation program causes net demand reductions, it almost always avoids this type of cost.

Over the long run, it is assumed that not only could variable operating costs be avoided because of reduced production levels, but that the ability to downsize or defer investments in new supply and/or infrastructure could result in additional 'long-run avoided costs'.

In order for water utilities to properly estimate direct avoided supply costs, they must carefully distinguish between and account for both types of costs. To the extent that they differ significantly across seasons or as a function of weather or hydrology, those differences must be reflected.

## BASELINE ASSUMPTIONS

To begin the analysis, the utility must provide the following baseline information. Each of these is essential to the computation of avoided costs.

- **Planning horizon**. Through what year does the planning period extend?
- **Escalation and discount rates**. How quickly will different types of costs increase over time, and what rate should be used to estimate the present value of time series of avoided costs?
- **Financing assumptions**. Over what period and at what interest rate will capital investments be financed?
- **Analytical time period**. Depending on the particular utility characteristics, it may or may not be important to distinguish between avoided costs in different seasons or, perhaps, months. If a seasonal distinction is to be made, the computation will need to know how many days are in each season (see below).
- **Demand forecast**. What is the demand forecast over the planning horizon for the time periods selected above. The demand forecast must reflect expected ongoing conservation—the water savings that will occur anyway (both 'passive conservation' that would occur without any additional utility conservation expenditures and 'active conservation' to which the utility has already committed).
- **Existing system components**. Key components of the existing supply and delivery system must be enumerated, including supply,[11] storage, treatment, and conveyance[12], along with the marginal operating costs associated with each.
- **New system components**. This includes those additions expected to be made over the planning horizon. Only those additions which are or may be a function of growing demand need be entered. For each new component, the expected on-line date, size, capital cost, fixed annual operating cost (if any), and marginal operating costs will be required.

## ESTIMATING SHORT-RUN AVOIDED COSTS

The key to estimating short-run avoided costs is to estimate, in each time period, the probability that each system component will be operating 'on the margin'.[13] As described

[11] Supply may include water purchases.

in Chapter 2, a component is said to be 'on the margin' if its operations would be cut back in response to conservation-induced demand reductions. In real time, the precise supplies, reservoirs, and treatment and conveyance facilities that would be cut back may be determined by a complex mix of economic, operational, regulatory, and other factors.

Some utilities have complex system simulation or other models to incorporate how these factors affect utility operations. The estimation approach does not presume that the utility has such a tool to simulate system operations, but does require that these 'on-margin' probabilities be estimated by the utility. For smaller utilities with less complex systems, this is likely to be a fairly simple exercise. For larger utilities, the probabilities may be the product of a simulation or other model. Alternatively, they will be educated guesses made by utility planning and operations staff. Utilities will be asked to provide 'on-margin' probabilities in a matrix such as Table 3-1.

**Table 3-1**
**Sample 'On-Margin' Probability Matrix**

| | | Supplies | | Storage | Treatment | | Conveyance Paths | | |
|---|---|---|---|---|---|---|---|---|---|
| **Existing Components or Planned Additions:** | | **Supply1** | **Supply2** | **Res1** | **Treat 1** | **Treat 2** | **Conv1** | **Conv2** | **Conv3** |
| ***Year*** | ***Time Period*** | | | | | | | | |
| **2005** | **Peak** | | | | | | | | |
| | **Off-Peak** | | | | | | | | |
| **2010** | **Peak** | | | | | | | | |
| | **Off-Peak** | | | | | | | | |
| **2015** | **Peak** | | | | | | | | |
| | **Off-Peak** | | | | | | | | |
| **2020** | **Peak** | | | | | | | | |
| | **Off-Peak** | | | | | | | | |
| **2025** | **Peak** | | | | | | | | |
| | **Off-Peak** | | | | | | | | |
| **2030** | **Peak** | | | | | | | | |
| | **Off-Peak** | | | | | | | | |

[12] As used here, the term 'conveyance' includes the entire water delivery system from source to customer.
[13] Of course, as demand grows and new system components are added over time, these probabilities may change.

In some time periods in some years, it may well be that a single supply source is always expected to be the marginal supply. If so, the entry for that supply would be 100%, with zero entries for the other supplies. (Since added variable operating costs may be incurred treating and/or conveying the water, there will likely also be additional nonzero entries in these categories.)

On the other hand, for other time periods, multiple supplies (or reservoirs or treatment plants) may have some likelihood of production cutbacks in response to demand reductions, depending on weather, hydrology, operating rules, etc. In that case, this matrix will reflect utility staff's best estimate of the probabilities that each unit is subject to cutback in response to conservation-induced savings.

The short-term avoided costs for each time period in each year in the matrix will be computed as the sum of the products of the variable operating cost for each system component and the corresponding probability.

## ESTIMATING LONG-RUN MARGINAL COSTS

The calculation of long-run marginal costs will be based on the degree to which the need for each planned addition can be deferred or downsized due to conservation-induced demand reductions. We must distinguish between demand reductions in different periods.

**Deferring or Downsizing Investments due to reductions in peak-period demands**. The approach recognizes that some investments could be deferred as a result of demand reductions, while others could be downsized. For each system addition, it must be determined whether that investment would be deferred, downsized, or neither due to conservation savings. While it is assumed that the primary driver of the need for each planned system addition is peak-period demand, it is also recognized that, in some cases, off-peak-season demand may also affect that need (see below).

In each future year, the sum of the annualized values of the deferrals and downsizings of all the additions with prior on-line dates is the *potential* peak-period marginal capacity cost. In many cases, the actual peak period marginal capacity cost will be equal to this potential cost. In some cases, however, it may be less.[14]

**Deferring or Downsizing Investments due to reductions in off-peak-period demands**. While conservation-induced demand reductions in the peak period will reduce the need for added capacity, there may be additional capacity benefits associated with demand reductions in other periods. This could occur, for example, if the utility has the ability to store all or a portion of the off-peak conserved water. In all cases, the value of off-peak demand reductions will be less than or equal to the value of peak-period reductions. In many cases, the value of demand reductions in off-peak periods will be zero.

The degree to which demand reductions in any time period affect the need for new supply will depend on the operational characteristics of the supply and delivery system. As is the case with estimating the 'on-margin' probabilities described above, the difficulty of estimating these parameters will depend on the complexity of the system and the modeling tools that are available.

In order to estimate period marginal capacity costs, utilities will be asked to fill in a matrix similar to Table 3-2, the entries of which are multipliers which express the degree to which the potential peak-period annualized capital and fixed O&M costs associated with each planned addition are avoided as a result of demand reductions in each period. An entry of 1.0 means that the full potential peak-period cost is avoided.

[14] The actual peak-period marginal capacity cost could be less than the potential cost if, for example, one or more system additions are intended to serve demand in only a portion of the service area.

**Table 3-2**
**Sample 'Period Multipliers' Matrix**

| | **Planned Additions:** | **Supply2** | **Treat2** | **Conv 3** |
|---|---|---|---|---|
| ***Year*** | ***Time Period*** | | | |
| **2005** | **Peak** | | | |
| | **Off-Peak** | | | |
| **2010** | **Peak** | | | |
| | **Off-Peak** | | | |
| **2015** | **Peak** | | | |
| | **Off-Peak** | | | |
| **2020** | **Peak** | | | |
| | **Off-Peak** | | | |
| **2025** | **Peak** | | | |
| | **Off-Peak** | | | |
| **2030** | **Peak** | | | |
| | **Off-Peak** | | | |

Based on the peak-period long-run marginal costs described above and the entries in this matrix, the avoided per-unit marginal capacity cost for each period in each year will be calculated.

## TOTAL AVOIDED COSTS

The total avoided cost per unit of conservation in each period in each future year is simply the sum of the short-run avoided costs and long-run avoided costs, making sure that they are properly expressed in the same units (e.g. dollars per million gallons or dollars per acre-foot).

*Beyond Avoided Costs: System Simulation*

The foregoing provides an approach to estimating any utility's avoided direct costs of supply. Additional detail is provided in Appendix A. The complexity of the approach reflects the underlying complexity of identifying and valuing the costs that are affected by conservation-induced demand reductions. The level of information required of a utility will be directly related to its size and the complexity of its system. For most smaller utilities, the data requirements, while not minimal, will be manageable.

However, particularly for larger, more complex systems, it is difficult for a spreadsheet model to capture all of the nuances of system operations that determine the cost impacts of different types of WUE programs. The avoided costs are a ‘shortcut’ to summarize that complexity. Under some circumstances, the use of a single quantity called the ‘avoided cost’ can be a poor approximation of the real world, and can therefore lead to erroneous conclusions.

An analytical alternative that, under some circumstances, provides more valid results is system simulation. As its name implies, a system simulation model seeks to replicate the manner in which a water supply system operates. Ideally, it will mimic many of the real-world physical and institutional operating constraints faced by system operators. Using such a model enables analysts to directly estimate the *total* costs with and without one or more conservation programs.[15] The difference in total cost provides the net benefit (or net cost) of the conservation program.[16]

Just as is the case with avoided cost, the analysis is predicated on an existing water supply plan, which lays out the types, sizes, and timing of supply and infrastructure additions over a planning horizon. The total cost of this plan includes two components: operating costs and capital costs. The operating costs can be further broken down into variable and fixed elements. Conservation programs will reduce both variable operating and capital costs.

Broadly speaking, this analysis would require the following steps:

1) Determine the total costs (capital and operating) required to maintain the desired level of water supply reliability over the planning period in the absence of conservation.
2) Introduce the conservation program(s) and determine the extent to which supply and/or facility investments can be deferred and/or downsized *while maintaining the same reliability level.*

[15] Simulation modeling cn also be used to more precisely estimate marginal costs.
[16] Of course, all costs are expressed in present value terms.

3) Re-compute the total costs.
4) Compare the reduction in supply and facility costs to the cost of the conservation programs themselves to determine if there is a net cost increase or decrease. If the conservation cost exceeds the cost reductions, the conservation programs are not economic; the opposite result indicates they are economic.

In order to best perform this type of analysis, the simulation model must have the following key features:

- **Resolution**. The model must be able to detect and respond to small increments of conservation in order to capture differences in water supply reliability.[17]
- **Different demand and hydrologic conditions**. The model must be able to simulate system operations under the range of demand and hydrologic conditions that reflect anticipated future variations in these key variables.
- **Time step**. The time step of the model simulations must be sufficiently short to capture important variations in system operations and performance. Thus, for example, if daily weather-driven variations in demand are an important driver of overall supply reliability, the ability to simulate a daily time step would be important.
- **Cost accounting**. The model must accurately account for revenue requirements associated with variable and fixed operating costs, as well as capital investments. It is easier, but not essential, that the costs associated with conservation programs also be accounted for within the model.
- **Changes in plan components**. Additions, deletions, deferrals, and changes in sizes of supplies, facilities, and conservation programs must be readily accomplished.

[17] In practice, the precision of most simulation models may not be sufficient to capture the impacts of many conservation programs. To address this problem, the water savings associated with a program(s) may be scaled up for modeling purposes. The resulting cost savings may then be scaled back down after the simulation modeling.

# CHAPTER 4: DATA SOURCES FOR ESTIMATING DIRECT UTILITY AVOIDED COSTS

## INTRODUCTION

The proposed method for estimating the avoided costs that result from water use efficiency has been outlined in the previous chapters. Depending upon the degree of detail required for a particular water utility, the approach may impose large data requirements. The purpose of this chapter is to provide guidance on potential data sources for the analyst responsible for estimating utility avoided costs.

For purposes of consistency, tracking, and quality control, each utility will be required to document the source(s) for each key assumption. In some cases, there will be a default source which the utility *must* use unless it provides a clear explanation of any deviation.

The data sources fall into one of four categories:

**1. Urban Water Management Plan (UWMP).** All urban water suppliers in the state of California are required to prepare an UWMP every five years (Water Code, Section 10620)[18]. Moreover, these filings include information that is directly relevant to some portions of the avoided cost calculation. Therefore, as described below, for certain data elements, the utility's most recent UWMP will be the designated **default data source**. In some cases, the data element must come directly out of the UWMP. In other cases, the avoided cost assumption should at least be consistent with information contained in the UWMP. This may be accomplished by using the underlying work papers and

[18] "Urban water supplier" is defined in Section 10617 of the Water Code as "a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually. An urban water supplier includes a supplier or contractor for water, regardless of the basis of right, which distributes or sells for ultimate resale to customers. This part applies only to water supplied from public water systems subject to Chapter 4 (commencing with Section 116275) of Part 12 of Division 104 of the Health and Safety Code."

documentation used to prepare the UWMP. In either event, the utility will be required to either provide evidence of the relationship to the designated table of the UWMP Template or to provide a clear explanation of the reason for any deviation.

**2. Other planning documents.** These may include, but are not limited to:

- Water Supply Assessments (SB 610, Statutes of 2001)
- Master planning or capital planning documents
- Water conservation plans
- Other planning reports
- Financial Plans or Statements

**3. Internal sources**. In many cases, the utility analyst will need to track down the original source of data elsewhere in the organization for specific data needs. While it is somewhat presumptuous to suggest to the analyst where to look in his/her own organization, generic suggestions are made where believed helpful.

**4. Published sources**. For some data needs, there are external published sources to which the analyst can turn. Where possible, specific sources are suggested or are designated as defaults.

## IDENTIFICATION OF DATA SOURCES

This section identifies the sources for the data associated with each of the analytical steps.

### Common Assumptions

*Planning Horizon*

*Internal*: Planning department

### Cost reference years

*Internal*: Planning and/or engineering departments

*Lost & unaccounted for water*

*UWMP default (direct)*: Water Code §10631 (e)(1)(2), see Table 14 of the UWMP Template.

**Time step** (annual, seasonal, or monthly)

*Internal*: Planning and/or operations departments. Note that the choice of the appropriate time step should be a function of the water system configuration and demand patterns, as well as the desired level of analytical complexity.

**Days in summer season** (only required if a seasonal time step is chosen)

*Internal*: Planning and/or operations departments

**Units**

*Internal*: Units for demand, capacity, volume, and costs should be determined by common usage by utility staff.

**Discount rate**

*For utility's costs, internal*: The analyst should be careful to maintain consistency with the discount rate used in other utility planning. Typically, the finance department provides an estimate of the "cost of capital" for planning purposes. For customers' costs where applicable, the OMB Circular rate.[19] Please refer to the discussion in the Council's *BMP Costs and Savings Study* for additional information on real v. nominal discount rates and discount rates from various perspectives.

[19] U.S. Office of Management and Budget, "Benefit-Cost Analysis of Federal Programs: Guidelines and Discount Rates," *Federal Register*, 53:519, - (Washington, D.C., November 19, 1994).

**Water Demands**

*UWMP default (consistency):* The required demand data is expected to be consistent with the data provided in the UWMP (Water Code §10631 (e)(1)(2)) of the utility's most recent UWMP, see Table 12-15 of the UWMP Template. Separating these into monthly or seasonal values for use in the model may require use of the background documentation used to develop the UWMP.

**Current & Planned System**

**Supply**

*UWMP default (consistency):* The enumeration of all existing and planned supply additions over the planning horizon is expected to be drawn directly from the UWMP the (Water Code § 10631 (b) and Water Code §10631 (h), see Tables 4 and 17 of the UWMP Template.)

*Storage, treatment, and conveyance*

*Internal*: Planning, engineering departments

**Variable Operating Costs (VOCs)**
**Reference year costs**

*Internal*: Operations

**Real escalation rates**

**Power**

*Published*: California Energy Commission (CEC) default (for consistency across utilities and agencies). The CEC publishes electric price forecasts by utility (http://www.energy.ca.gov/electricity/index.html#rates). It is expected that the growth rates embedded in these will be used to estimate the average annual real escalation rate for power costs over the planning horizon.

**Chemicals**

*Published*: accepting nominations for sources.

**Other**

*Published*: accepting nominations for sources.

**On-Margin Probabilities**

*Internal*: Planning and/or operations departments.

**Planned System Additions**

*Size and on-line date*

*UWMP default (direct):* It is expected that the magnitude and expected on-line date of planned system additions will be drawn directly from the most recent UWMP (Water Code §10631 (h), see Table 17 of the UWMP Template.).

**Reference year capital and annual fixed O&M costs**

*Internal*: Planning, engineering and/or finance departments

**Capital and fixed O&M cost real escalation rates**

*Published or Internal*: The California Dept. of Finance has provided forecasts of escalation rates, or may have a suggestion for where to get those. (DWR and the CEC get their forecasts from DOF).

**Geographic adjustment factor, fixed or variable on-line date, and deferral/downsize ratio**

*Internal*: Planning department

**Financing assumptions**

*Internal*: Finance department. These need to be consistent with the discount rate assumptions above.

**Period Multipliers for Planned Additions**

*Internal*: Planning, operations departments

# APPENDIX A: CUWCC AVOIDED COST MODEL OPERATING INSTRUCTIONS

## INTRODUCTION

The CUWCC Avoided Cost Model is an Excel spreadsheet that estimates two water utility avoided cost components:

- **Short-run Avoided Costs**. These are the costs that are immediately avoided by the water utility due to the reduced water production that results from the conservation-induced demand reductions.

- **Long-run Avoided Costs**. Conservation-caused demand reductions also may allow the deferral and/or downsizing of planned supply or facility additions and expansions. The model estimates the economic value to the water utility of these conservation-induced investment modifications.

Each of these components is estimated for each year of a user-supplied planning period. The model estimates each year's avoided costs for user-defined peak and off-peak seasons.

The approach requires the user to have information about the existing water supply, storage, treatment, and conveyance system as well as the utility's plans for adding components to that system. This information requires substantial knowledge of the utility's water planning, operations, and capital improvement programs. This model will have the most value - and the most credible output - if appropriate conservation, planning, operations, finance, and engineering staff work together to assure that input data is as accurate as possible.

The specific informational requirements are detailed below.

***All cells in which user inputs are required are outlined in red***. The model inputs and outputs are on a series of worksheets, which follow the underlying computational logic. Following are descriptions of the inputs, computational logic, and outputs of each worksheet. Screen shots of each sheet are provided.

The avoided costs developed by this model are intended to be used in benefit-cost analyses of utility water conservation programs. The avoided costs themselves are not program-specific. They are a function of the utility's current forecasted demands, supplies, and infrastructure. Their use rests on the assumption that the magnitude of the expected savings from the conservation programs for which these avoided costs will be used to calculate utility benefits, is small compared to total system demands.

Appendix B includes a set of detailed examples of how the model could be used in different utility configurations. The examples begin with simple cases and increase in complexity.

## COMMON ASSUMPTIONS (SEE FIGURE 1)

Required inputs on this sheet include the following:

Analysis Start Year. The year in which the computation of avoided costs is to begin.

Planning Horizon. The year through which avoided costs are to be computed. After this year, the model will automatically set the avoided costs to zero. The planning horizon should correspond to that used in other utility planning processes.

By clicking on 'Update Tables' after entering the Analysis Start Year and the Planning Horizon Year, the model will automatically adjust input tables to conform to these entries.

Cost-Reference Year. The year dollars in which all cost inputs are expressed (e.g. 2005 dollars).

Lost and Unaccounted for Water. This is the first of two locations where the user can enter an estimate for system losses. This entry is an overall system-wide LUAF rate expressed as a percent. This rate is intended to reflect an overall average loss rate from source to meter. The model will divide all variable operating costs and revenues associated with water supply and storage components (see Variable Operating Costs sheet below) by one minus this factor to estimate an equivalent cost at the customer meter.

Since losses to the meter will likely differ at different points in the system, this single rate can be no more than an approximation. Therefore, the model also allows the user to enter component-specific losses for supply and storage components (see Variable Operating Costs sheet). The calculation of costs at the meter will apply this system-wide LUAF rate as well as the appropriate component specific loss rate. *The user must therefore take care not to double count losses.* For example, if all losses are reflected in the component-specific rates, this system-wide rate should be set to zero. If, on the other hand, the user wishes to account for all losses through this single system-wide rate, then the component-specific losses should be set to zero.

A blank is read as zero.

Peak-Season Start and End Dates. The dates which define the beginning and end of the peak season for purposes of the avoided cost calculation, entered in the format xx/xx (month/day).

Projected Interest Rate. The projected interest rate over the planning period, which will be used to compute annualized capital costs (see Long Run Avoided Cost calculation below). A blank is read as zero.

Projected Inflation Rate. The projected inflation rate over the planning period, which will be allow the model to express results in both real and nominal terms (see below). A blank is read as zero.

Units of Measurement. The user is asked to specify the units in which inputs will be provided and outputs will be expressed, as follows:

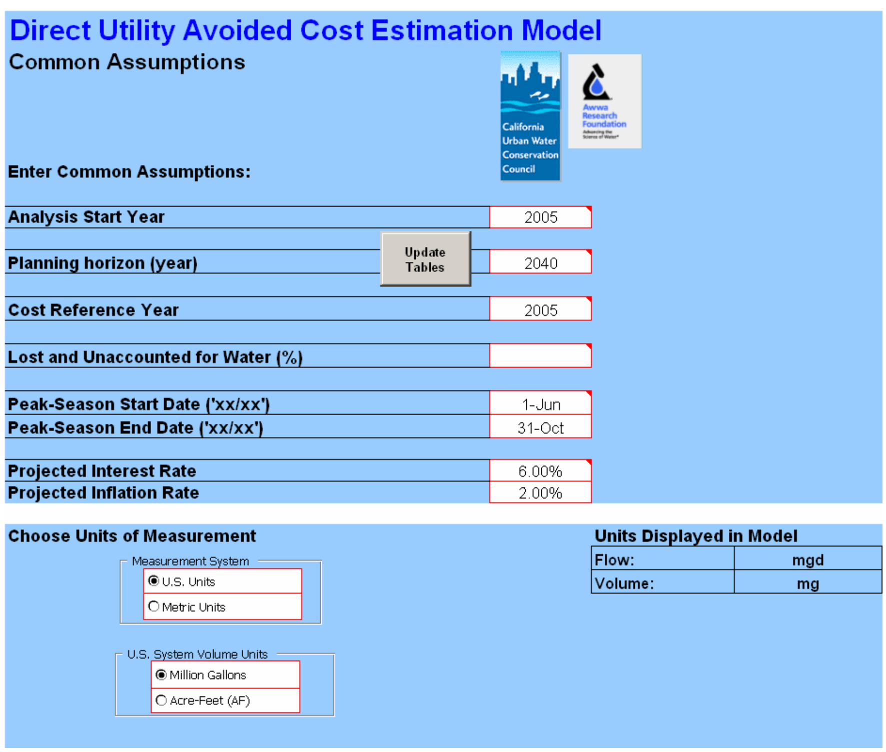
- Measurement System: The user must choose U.S. or Metric.

  If U.S. units are selected:
    - Volume: The user must indicate whether water volumes will be expressed as millions of gallons or acre-feet.
    - Flow: U.S. flow units are assumed to be expressed as millions of gallons per day (mgd).

  If Metric units are selected:
    - Volume: Metric volumes are assumed to be expressed as cubic meters.
    - Flow: Metric flows are assumed to be expressed as cubic meters per day.

Based on the user selections, the grid to the right shows the flow and volume units that the model will use. All inputs and outputs will be expressed in these units.

**Figure 1**
**Common Assumptions Sheet**



## DEMANDS (SEE FIGURE 2)

On this sheet, the user must supply a seasonal demand forecast. Demands are at the customer meter. The user must first indicate whether the inputs are expressed as total seasonal volumes or as seasonal average daily flows. In either case, the units are as specified on the Common Assumptions sheet. Based on these inputs, the model computes the year-to-year seasonal demand growth, and the 'deferral periods' associated with a peak-season demand reduction of one daily flow unit (i.e. mgd or cu mtr/day). The deferral period is the period that certain investments (see below) can be deferred without adversely affecting water supply reliability. For example, if, at any point in time, the year-to-year growth in peak-season demand is 2 mgd, each 1 mgd demand reduction will result in a deferral period of 0.5 years. The deferral periods will be used (see below) in the calculation of long-run avoided costs.

Note that the model's long-run avoided cost calculation (see below) requires demands to be increasing over the planning period.

## SHORT-RUN AVOIDED COST CALCULATION

## VARIABLE OPERATING COSTS (SEE FIGURE 3)

On this sheet, the user enters the variable operating costs (VOCs) and variable operating revenues (VORs) for existing and planned system components. VOCs and VORs are those costs and revenues that vary with the production or throughput of the system component.

For the purposes of estimating direct utility avoided costs, only those system components with *non-zero* VOCs or VORs need be entered.[20]

Before entering data on this sheet, users should click on 'Number of Components' and enter a number no greater than 25. The data-entry matrix will be sized accordingly. If the user wishes to revise the number of entries, simply click 'Number of Components' again and make a new entry.

To ensure that hidden data does not inadvertently affect the avoided cost calculation, data entries for planned additions beyond the 'Number of Components' are automatically blanked out or set to zero. Thus, for example, if there are already data entries for five system components, and the user then clicks 'Number of Components' and enters 4, the data for the last of the five components will be lost. The data for the first four components will remain.

[20] Since the CUWCC environmental benefits model will be utilizing the system components identified here, California users are asked to also enter any system component for which conservation-induced usage reductions may have significant environmental benefits.

**Figure 2**
**Demands Sheet**

| Forecasted Demands | | | | | |
|---|---|---|---|---|---|
| Demand Data Entry Units: | Flow | | | | |
| | Seasonal Demand | | Annual Demand Growth | | Peak Season |
| | Peak | Off-Peak | Peak-Season | Off-Peak Season | 1 mgd Deferral Periods |
| Year | (mgd) | (mgd) | (mgd) | (mgd) | (years) |
| 2005 | 200.0 | 100.0 | 4.0 | 2.0 | 0.250 |
| 2006 | 204.0 | 102.0 | 4.1 | 2.0 | 0.245 |
| 2007 | 208.1 | 104.0 | 4.2 | 2.1 | 0.240 |
| 2008 | 212.2 | 106.1 | 4.2 | 2.1 | 0.236 |
| 2009 | 216.5 | 108.2 | 4.3 | 2.2 | 0.231 |
| 2010 | 220.8 | 110.4 | 4.4 | 2.2 | 0.226 |
| 2011 | 225.2 | 112.6 | 2.3 | 1.1 | 0.444 |
| 2012 | 227.5 | 113.7 | 2.3 | 1.1 | 0.440 |
| 2013 | 229.8 | 114.9 | 2.3 | 1.1 | 0.435 |
| 2014 | 232.1 | 116.0 | 2.3 | 1.2 | 0.431 |
| 2015 | 234.4 | 117.2 | 2.3 | 1.2 | 0.427 |
| 2016 | 236.7 | 118.4 | 2.4 | 1.2 | 0.422 |
| 2017 | 239.1 | 119.5 | 2.4 | 1.2 | 0.418 |
| 2018 | 241.5 | 120.7 | 2.4 | 1.2 | 0.414 |
| 2019 | 243.9 | 121.9 | 2.4 | 1.2 | 0.410 |
| 2020 | 246.3 | 123.2 | 2.5 | 1.2 | 0.406 |
| 2021 | 248.8 | 124.4 | 1.2 | 0.6 | 0.804 |
| 2022 | 250.0 | 125.0 | 1.3 | 0.6 | 0.800 |
| 2023 | 251.3 | 125.6 | 1.3 | 0.6 | 0.796 |
| 2024 | 252.5 | 126.3 | 1.3 | 0.6 | 0.792 |
| 2025 | 253.8 | 126.9 | 1.3 | 0.6 | 0.788 |
| 2026 | 255.1 | 127.5 | 1.3 | 0.6 | 0.784 |
| 2027 | 256.4 | 128.2 | 1.3 | 0.6 | 0.780 |
| 2028 | 257.6 | 128.8 | 1.3 | 0.6 | 0.776 |
| 2029 | 258.9 | 129.5 | 1.3 | 0.6 | 0.772 |
| 2030 | 260.2 | 130.1 | 1.3 | 0.7 | 0.769 |
| 2031 | 261.5 | 130.8 | 1.3 | 0.7 | 0.765 |
| 2032 | 262.8 | 131.4 | 1.3 | 0.7 | 0.761 |
| 2033 | 264.1 | 132.1 | 1.3 | 0.7 | 0.757 |
| 2034 | 265.5 | 132.7 | 1.3 | 0.7 | 0.753 |
| 2035 | 266.8 | 133.4 | 1.3 | 0.7 | 0.750 |
| 2036 | 268.1 | 134.1 | 1.3 | 0.7 | 0.746 |
| 2037 | 269.5 | 134.7 | 1.3 | 0.7 | 0.742 |
| 2038 | 270.8 | 135.4 | 1.4 | 0.7 | 0.739 |
| 2039 | 272.2 | 136.1 | 1.4 | 0.7 | 0.735 |
| 2040 | 273.5 | 136.8 | 1.4 | 0.7 | 0.731 |

User entries on this sheet are as follows:

<u>Type</u>. Drop-down menus allow users to specify the type of system component. Options include:

- 'Su' is a water supply. These include surface and groundwater supplies, as well as purchases.

- 'St' is a surface or groundwater storage facility.

- 'T' is a treatment plant.

- 'CP' is a conveyance path. As used here, the term 'conveyance' includes the entire water delivery system, from source to customer.[21] For many water utilities, the conveyance network is quite complex, and may include a very large number of raw and treated water nodes and links. In terms of data and analytical requirements, it would be unreasonable to expect anything like a complete enumeration of the components of the conveyance system.

  Fortunately, for purposes of estimating avoided variable operating costs, such an enumeration is unnecessary. Instead, the user is asked to define *groupings of conveyance paths*. A *conveyance path* represents one way of moving water from a supply point to the customer. *Each group of conveyance paths will consist of paths with similar non-zero pumping costs*.[22]

  For most delivery systems, the vast majority of conveyance paths will not require any pumping, and those paths need not be considered. Those paths that do require pumping should be grouped according to approximate pumping cost. The user must determine the most sensible way to define groups that represent reasonable clusters of pumping costs. These groups must strike a balance between precision and manageability. It is *not* necessary for every path in a particular group to have *precisely* the same pumping cost. Rather, the paths in a group will have pumping costs that are close to one another.

<u>Component Name</u>. Users should enter a name for each system component.

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[21] It is recognized that different utilities use different names for differing components of what is being called the 'conveyance' system, including 'conveyance', 'transmission', 'distribution', etc.

[22] If a utility includes treatment, and its associated variable operating costs, in the conveyance paths, the variable operating costs for treatment should not be accounted for separately.

**Figure 3**
**Variable Operating Costs Sheet**

| Number of Components? | | | | Variable Operating Costs | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Component Type | Component Name | Existing or Planned? | On-Line Year (for Planned) | Loss Rate | Power Costs (2005 dollars) | Chemical Costs (2005 dollars) | Purchase Costs (2005 dollars) | Other Costs (2005 dollars) | Revenues (2005 dollars) |
| | | | | | ($/mg) | ($/mg) | ($/mg) | ($/mg) | ($/mg) |
| Su | Diversion A | e | | 5% | $20 | | | | $10 |
| T | WTP A | e | | | $150 | $75 | | | |
| Su | GW #1 | p | 2015 | 20% | $100 | | | | |
| CP | Path Group 25 | e | | | $25 | | | | |
| CP | Path Group 50 | p | 2010 | | $50 | | | | |
| | | | Annual Real Escalation Rates: | | 1.00% | 0.00% | 2.00% | 0.00% | 0.00% |

Existing or Planned? Users should enter 'e' if the component is a part of the existing system, or 'p' if the component is a future planned addition. Planned additions do not include expansions of existing system components, unless they substantially change the variable operating costs or revenues of that component. For example, an expansion of an existing treatment plant that does not change the power or chemical costs to treat each unit of water on site need not be included here, nor must a dam raise that increases the stored water capacity but does not affect the per-unit operating cost of the reservoir.[23] On the other hand, a planned addition to the conveyance system that creates a new group of conveyance paths with different cost characteristics should be included.

On-Line Year. For planned additions, the year in which the component is planned to come on-line should be entered. For existing components, this entry should be left blank.

Loss Rate. The component-specific percentage loss rate to the customer meter. As described above, *these rates are in addition to the system-wide LUAF rate entered on the Common Assumptions sheet.* Loss rates can only be entered for supply or storage components. For treatment plants and conveyance paths, the loss rate cell will be shaded, indicating no user input.

Power Costs. For both existing and planned system components, the unit power costs, expressed in the dollars of the cost reference year and denominated in the volumetric units specified (see Common Assumptions), should be entered. Note that the power costs that are of concern here are only those that vary with energy consumption. Put another way, the entry here should be based on the *marginal energy rate* paid by the water utility

[23] Potential changes in the usage of these facilities due to the expansions are reflected in the on-margin probabilities (see below). The capital costs associated with such expansions will be dealt with below in the discussion of long-run avoided costs.

rather than its average energy cost. This determination will depend on the utility's particular energy rate schedule. A blank is read as zero.

Chemical Costs. For both existing and planned system components, the unit chemical costs, expressed in the dollars of the cost reference year and denominated in the volumetric units specified (see Common Assumptions), should be entered. A blank is read as zero.

Purchase Costs. For both existing and planned water purchases, the unit purchase price, expressed in the dollars of the cost reference year and denominated in the volumetric units specified (see Common Assumptions), should be entered. Note: Similar to the power costs discussed above, the portion of the purchase price that is of concern is not the average but the marginal price. A blank is read as zero.

Other Costs. For both existing and planned system components, any other variable operating costs not included in the other three categories, expressed in the dollars of the cost reference year and denominated in the volumetric units specified (see Common Assumptions), should be entered. For example, to the extent that any labor costs vary with production levels, these costs can be entered here.[24] A blank is read as zero.

Revenues. If any revenues change as a function of the operation of a system component (e.g. revenues from the sale of hydropower), an entry should be made in this column. These entries can have either a positive or negative value. A *positive* entry indicates that the change in revenues *has the same sign* as the change in the production or throughput level of the component. That is, as the production/throughput increases or deceases, the revenues will do likewise. Thus, a positive entry indicates that a conservation-induced cutback in production would lead to a decrease in revenues.

A *negative* entry indicates that the change in revenues *has the opposite sign* as the change in the production or throughput level of the component.

A blank is read as zero.

Annual Real Escalation Rates. For each cost/revenue component, the user must specify a real (net of inflation) annual escalation rate, as a percentage. A blank is read as zero.

**Note on Seasonal Cost/Revenue Variation**

If, for any system component, the user wishes to reflect significant seasonal differences in one or more of the VOCs/VORs, it is suggested that the user enter two system components, one with the peak-season VOCs/VORs and one with the off-peak season

[24] More typically, labor costs do not vary with production levels, in which case they should be included as part of the annual fixed operating costs discussed below. If a portion of labor costs is variable, the user should take care to carefully distinguish between, and not double count, the variable and fixed labor costs.

VOCs/VORs. The on-margin probabilities (see below) should then reflect the fact that each component only operates in one season.

## ON-MARGIN PROBABILITIES (SEE FIGURE 4)

The user must specify the probability that each system component identified above is operating 'on the margin' in each season for each five year interval. These probabilities must be entered as percentages. A blank will be read as zero.

A component is said to be 'on the margin' if its operations would be cut back in response to conservation-induced demand reductions. In real time, the precise supplies, reservoirs, and treatment and conveyance facilities that would be cut back may be determined by a complex mix of economic, operational, regulatory, institutional, and other factors.

The probability that a component is on the margin is *not* the same as the probability that a component will be used. For example, a supply that is base loaded may be running 100% of the time, but may seldom or never be subject to cut back in response to conservation savings. The on-margin probability for such a supply will be close to zero.

The matrix on this worksheet recognizes two essential points:

- The on-margin probabilities may vary by season. Winter demands are typically lower and source availabilities, water rights, operating constraints, etc. differ between the seasons.

- As demands grow and as new system components are added, operating patterns could change over time. The on-margin probabilities may likewise change.

Since, as discussed above, the calculation of short-run avoided costs is only concerned with those system components with nonzero VOCs/VORs, the on-margin probabilities within categories (e.g. 'supply and storage') may add to less than 100%. However, in any season, the total on-margin probabilities within a category may not exceed 100%. An error message will appear at the beginning of the row if this condition is violated. [25]

[25] Categories include: (1) Supply and storage; (2) Treatment; (3) Conveyance paths

**Figure 4**
**On-Margin Probabilities Sheet**

**System Components:**
**On-Margin Probabilities**

| Year | Season | | Diversion A | WTP A | GW #1 | Path Group 25 | Path Group 50 |
|---|---|---|---|---|---|---|---|
| | | *On-line dates:* | | | *2015* | | *2010* |
| **Year** | **Season** | *Type:* | *Su* | *T* | *Su* | *CP* | *CP* |
| 2005 to 2009 | Peak | | 100% | 100% | 0% | 20% | 0% |
| | Off-Peak | | 100% | 100% | 0% | 10% | 0% |
| 2010 to 2014 | Peak | | 70% | 100% | 0% | 20% | 30% |
| | Off-Peak | | 80% | 100% | 0% | 10% | 20% |
| 2015 to 2019 | Peak | | 50% | 100% | 30% | 30% | 30% |
| | Off-Peak | | 80% | 100% | 10% | 10% | 20% |
| 2020 to 2024 | Peak | | 40% | 100% | 30% | 30% | 25% |
| | Off-Peak | | 80% | 100% | 10% | 10% | 20% |
| 2025 to 2029 | Peak | | 45% | 100% | 40% | 40% | 25% |
| | Off-Peak | | 85% | 100% | 10% | 10% | 15% |
| 2030 to 2034 | Peak | | 55% | 100% | 40% | 50% | 20% |
| | Off-Peak | | 90% | 100% | 10% | 10% | 10% |
| 2035 to 2039 | Peak | | 55% | 100% | 40% | 50% | 20% |
| | Off-Peak | | 90% | 100% | 10% | 10% | 10% |
| 2040 to 2044 | Peak | | 55% | 100% | 40% | 50% | 20% |
| | Off-Peak | | 90% | 100% | 10% | 10% | 10% |

Note: Prior to the on-line date of any planned addition, that component's on-margin probabilities for each year and each season must be zero. An error message will appear at the top of the column if this condition is violated.

The manner in which users estimate these on-margin probabilities will differ among utilities. For many utilities, the process will be straightforward, while for others it may be less so. Those utilities (especially larger ones with more complex systems) that have system simulation or other relevant modeling tools may use them to estimate the on-margin probabilities. Those that do not have such models must use the best collective knowledge and expertise of planning and operations staff to populate this matrix. For smaller utilities with less complex systems, this is likely to be a fairly simple exercise.

The on-margin probabilities can, if applicable, also reflect geographic limitations. If, for example, physical, contractual, and/or institutional constraints limit a particular water supply source to supplying only a portion of the service area which accounts for, say, 50% of service area demands, then the on-margin probabilities for that supply will be

50% of what it otherwise would have been if the supply was able to serve the entire service area.[26]

While it is expected that each utility will develop its own estimation strategy, in some cases, it may be useful for the utility to separately estimate the on-margin probabilities for several different conditions (e.g. weather and/or hydrology), and compute a weighted average of those probabilities. The model provides three *optional* worksheets that may be used to represent such conditions, as well as a 'weighted average' sheet which computes the weighted average of the condition-specific probabilities. The weights at the top of the condition sheets must add up to 100%. An error message will appear if this is not the case. *Use of these sheets is solely at the discretion of the user. If the user chooses to use these sheets, he/she must manually copy the weighted average results to the 'On-Margin Probabilities' worksheet.*

It is recognized that the estimation of the on-margin probabilities is inherently imprecise, particularly for larger, more complex systems. It is therefore suggested that sensitivity testing be done to assess the degree to which the short-run avoided costs are affected by reasonable ranges of these parameters.

## SHORT-RUN AVOIDED COSTS (SEE FIGURE 5)

On this worksheet, the model calculates the short-run avoided costs for each season in each year, expressed in nominal and real terms. The calculation is based on the variable operating costs, inflation and real escalation rates, system-wide and component-specific loss rates, and on-margin probabilities provided by the user. *No user inputs are permitted on this sheet.*

[26] It is recognized that real-world limitations may also reflect the geographic target area of each conservation program. Such factors cannot be reflected in this avoided cost model, which assumes, in essence, that the geographic distribution of the conservation savings themselves do not constrain the calculation of avoided costs. Such program-specific issues must be handled elsewhere.

**Table 5**
**Short-Run Avoided Costs Sheet**

## Short-Run Avoided Costs
## ($/mg)

| Annual Short-Run Avoided Costs by Season Nominal Dollars | | | Annual Short-Run Avoided Costs by Season 2005 Dollars | | |
|---|---|---|---|---|---|
| Year | Peak-Season | Off-Peak Season | Year | Peak-Season | Off-Peak Season |
| 2005 | $240.53 | $238.03 | 2005 | $240.53 | $238.03 |
| 2006 | $247.13 | $244.56 | 2006 | $242.29 | $239.76 |
| 2007 | $253.93 | $251.27 | 2007 | $244.06 | $241.51 |
| 2008 | $260.91 | $258.18 | 2008 | $245.86 | $243.29 |
| 2009 | $268.09 | $265.28 | 2009 | $247.67 | $245.07 |
| 2010 | $289.04 | $281.62 | 2010 | $261.79 | $255.07 |
| 2011 | $297.01 | $289.37 | 2011 | $263.73 | $256.95 |
| 2012 | $305.20 | $297.35 | 2012 | $265.69 | $258.86 |
| 2013 | $313.62 | $305.55 | 2013 | $267.68 | $260.78 |
| 2014 | $322.29 | $313.98 | 2014 | $269.68 | $262.72 |
| 2015 | $381.95 | $339.48 | 2015 | $313.34 | $278.49 |
| 2016 | $392.62 | $348.90 | 2016 | $315.77 | $280.61 |
| 2017 | $403.59 | $358.60 | 2017 | $318.23 | $282.75 |
| 2018 | $414.88 | $368.57 | 2018 | $320.72 | $284.91 |
| 2019 | $426.49 | $378.82 | 2019 | $323.23 | $287.10 |
| 2020 | $432.65 | $389.36 | 2020 | $321.47 | $289.30 |
| 2021 | $444.75 | $400.21 | 2021 | $323.97 | $291.53 |
| 2022 | $457.19 | $411.36 | 2022 | $326.51 | $293.78 |
| 2023 | $469.98 | $422.83 | 2023 | $329.06 | $296.05 |
| 2024 | $483.15 | $434.63 | 2024 | $331.65 | $298.35 |
| 2025 | $525.01 | $443.36 | 2025 | $353.32 | $298.37 |
| 2026 | $539.80 | $455.75 | 2026 | $356.15 | $300.69 |
| 2027 | $555.01 | $468.49 | 2027 | $359.00 | $303.04 |
| 2028 | $570.67 | $481.60 | 2028 | $361.89 | $305.41 |
| 2029 | $586.77 | $495.08 | 2029 | $364.81 | $307.80 |
| 2030 | $606.04 | $505.04 | 2030 | $369.40 | $307.84 |
| 2031 | $623.19 | $519.20 | 2031 | $372.40 | $310.26 |
| 2032 | $640.82 | $533.76 | 2032 | $375.43 | $312.71 |
| 2033 | $658.97 | $548.74 | 2033 | $378.50 | $315.18 |
| 2034 | $677.64 | $564.15 | 2034 | $381.59 | $317.68 |
| 2035 | $696.86 | $580.00 | 2035 | $384.71 | $320.20 |
| 2036 | $716.62 | $596.30 | 2036 | $387.87 | $322.75 |
| 2037 | $736.96 | $613.07 | 2037 | $391.06 | $325.32 |
| 2038 | $757.89 | $630.33 | 2038 | $394.27 | $327.92 |
| 2039 | $779.42 | $648.08 | 2039 | $397.52 | $330.54 |
| 2040 | $801.57 | $666.34 | 2040 | $400.81 | $333.19 |

## LONG-RUN AVOIDED COST CALCULATION

## INTRODUCTION

The calculation of long-run avoided costs is based on the degree to which each planned system addition would be either *deferred* or *downsized* as a result of conservation-induced demand reductions. For each planned addition, the user must indicate whether it would be deferred or downsized. Only those planned additions which would either be deferred or downsized in response to demand reductions affect the avoided cost calculation. In both cases, the model logic recognizes that, while the primary driver of the long-run avoided cost is the peak-season demand reduction, the off-peak season may also have some impact. (See discussion below.)

### Planned Additions Subject to Deferral: Peak Season Demand Reductions

Planned additions whose timing is a function of future water demand growth are assumed to be deferrable in response to conservation-induced demand reductions. For those planned additions, the model logic assumes that the timing of the project is deferred, but the size and real-dollar cost of the project remains unchanged.[27] The *deferral periods* calculated on the Demands sheet (see above) determine the duration of potential deferral in response to each unit of peak-season demand savings.

For example, if peak-season demand is projected to be growing at a rate of 4 mgd per year in the year that a particular addition is scheduled to come on-line, then the maximum period that each mgd of peak-period conservation will defer that investment is 0.25 years. This deferral reduces the annualized cost of the planned addition, and this reduced annualized cost is the *potential* annual peak-season avoided capacity cost associated with this addition, beginning with the expected on-line date and lasting through the user-specified financing term (see below). A similar calculation is performed for each deferrable planned system addition.

### Planned Additions Subject to Downsizing: Peak Season Demand Reductions

Planned additions whose *timing* is not a function of future demands but whose *size* does vary with future demands are subject to a different long-run avoided cost logic. For those planned additions, the model logic assumes that the size of the associated capital investment and fixed annual O&M costs are reduced as a function of the peak-season demand reduction in the scheduled on- line year. The user is permitted to specify a ‘downsize factor’ which determines how much the costs will be reduced.

For example, if we assume a 10 mgd project size and a 1 mgd demand reduction, the capital and fixed O&M costs will each be reduced by 10% if the ‘downsize factor’ is 1.0. If, however, the user sets that fraction at 0.5, the costs would be reduced by 5%.

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[27] That is, the only change in cost from the cost reference year is due to inflation.

Before specifying more than one project as being subject to downsizing, it is critical that the user think through the potential relationships among those projects. For example, the potential effect of downsizing an earlier project on the ability to downsize a later project must be considered. Otherwise, the potential exists for a significant overstatement of avoided costs. One possible way to reflect these relationships is in the 'downsize factors'.

**Peak Season and Off-Peak-Season Demand Reductions**

The model logic assumes that the primary driver of project deferrals or downsizings is the reduction in peak-season demand. However, the model also recognizes that reductions in off-peak-season demands can also result in avoided costs if the utility has the ability to store all or a portion of the off-peak conserved water. It is expected that the value of off-peak demand reductions will always be less than or equal to the value of peak-season reductions. In many cases, the value of demand reductions in the off-peak season will be zero.

Accounting for the benefits of peak and off-peak savings will be discussed in more detail below (see Seasonal Multipliers).

## PLANNED ADDITIONS (SEE FIGURE 6)

This worksheet begins the calculation of the long-run avoided costs. Here, the user provides additional information about each planned system capital addition.

Before entering data on this sheet, users should click on 'Number of Projects' and enter a number no greater than 10. The data-entry matrix and the output tables will be sized accordingly. If the user wishes to revise the number of entries, simply click 'Number of Projects' again and make a new entry.

To ensure that hidden data does not inadvertently affect the avoided cost calculation, data entries for planned additions beyond the 'Number of Projects' are automatically blanked out or set to zero. Thus, for example, if there are already data entries for five system components, and the user then clicks 'Number of Projects' and enters 4, the data for the last of the five planned additions will be lost. The data for the first four projects will remain.

User entries on this sheet are as follows:

Project Name. The user must enter the names of all system additions that are planned to come on line during the planning period and which could be either deferred or downsized as a result of conservation-induced demand reductions. While these system additions may

**Figure 6**
**Planned System Additions Sheet**

**Planned System Additions**

**Number of Projects?**

| Project Name | On-line Year | Capital Cost | Fixed O&M Cost | Defer/ Downsize? | If Downsize, then: Downsize Factor | Flow/ Volume? | Size Units | Size (Peak Season) |
|---|---|---|---|---|---|---|---|---|
| | | ($million)<br>Year 2005 Dollars | ($/yr)<br>Year 2005 Dollars | | | | | |
| GW # 1 | 2015 | $10 | | do | 0.8 | f | mgd | 10 |
| Reservoir North | 2010 | $100 | $100,000 | de | | | | |
| Pipeline North | 2011 | $20 | | de | | | | |
| WTP B | 2024 | $5 | $25,000 | do | 1 | f | mgd | 5 |
| Pipeline South | 2024 | $50 | | de | | | | |
| **Annual Real Escalation Rates:** | | 1% | 1% | | | | | |
| **Financing Term (yrs):** | 20 | | | | | | | |

coincide with the planned system components identified on the Variable Operating Costs sheet (see above), this is not necessarily the case (although the two sets will likely overlap). As described above, the planned additions that are relevant to the short-run avoided cost calculation include only those which have non-zero variable operating costs or revenues which differ substantially from an existing system component (or, for California users, those which may have significant environmental benefits). The system additions that are of concern in this calculation of long-run avoided costs include all capital investments that could be deferred or downsized as a result of demand reductions.

For example, whereas the short-run marginal cost calculation may include a planned water purchase, this new supply is not included in the long-run calculation, since there is no capital investment involved. On the other hand, the long-run calculation may include a raise of an existing dam, which is not included in the short-run calculation because no change in variable operating costs is involved. Many projects affect both the short-run and long-run avoided costs calculations, and therefore appear in both places.

<u>On-Line Year</u>. The user must enter the year each planned addition is expected to become operational. <u>The on-line year may not precede the Analysis Start Year specified in Common Assumptions. If it does, an error message will appear</u>.

<u>Capital Cost</u>. The user must enter the estimated capital cost of each planned addition, expressed in millions of reference year dollars. (Recall that the cost reference year is specified in Common Assumptions). These capital costs should include such things as estimating allowances, construction contingencies, and engineering, legal, and administrative allowances. As appropriate, they should also include environmental mitigation.

Fixed O&M Cost. The user must enter the estimated annual fixed operating and maintenance costs associated with each planned addition, also expressed in the dollars of the cost reference year specified in Common Assumptions. These costs are distinct from the variable operating costs that form the basis of the short-run avoided cost calculation, in that they do not change as a function of production or throughput. Labor costs are typically the largest portion of this cost component. A blank entry is read as zero.

Defer/Downsize?. For each planned addition, the user must indicate whether that addition can be deferred ('de') or downsized ('do'). As described above, this will determine the avoided cost calculation logic to be used by the model. *A planned addition for which this entry is blank will be assumed to be deferrable.*

**NOTE: The following three entries need only be made for projects that can be *downsized*. The model will ignore these entries for deferrable projects.**

> Downsize Factor. The user is asked to enter a factor which indicates the degree to which project capital and annual fixed O&M costs are reduced in response to peak-season demand reductions. A factor of 1.0 results in the costs being reduced proportionally. A factor less than 1.0 results in costs being reduced less than proportionally. *The model reads a blank entry as a factor of 1.0.*
>
> Flow/Volume?. The user must specify whether the model should read the size units as a flow or as a volume. Enter 'f' or 'v'. *If this cell is left blank, the model assumes that the size is expressed as a flow.* Based on this selection, the model will indicate the units in which the project size should be expressed.
>
> Size. The user must enter the size of the unit, expressed as a flow or a volume, as indicated above. The size, whether expressed as flows or volumes, is for the peak season. Thus, for example, a billion-gallon reservoir can either be expressed as 1000 million gallons (a volume) or, assuming a 150-day peak season, as 6.7 mgd.[28] Similarly, a 5 mgd groundwater supply can either be expressed as 5 mgd (a flow) or as 750 million gallons (assuming the same 150-day peak season).

Annual Real Escalation Rates. For each cost component, the user must specify a real (net of inflation) annual escalation rate, as a percentage. A blank is read as zero.

Financing Term. The number of years over which the utility would expect to finance the capital investments.

[28] Depending on the manner in which the reservoir is operated, the available peak-season volume or flow may be less than the physical reservoir capacity.

**SEASONAL MULTIPLIERS (SEE FIGURE 7)**

In order to estimate period marginal capacity costs, users are required to fill in a table of 'seasonal multipliers', which express the degree to which the total annualized capital and fixed O&M costs associated with each planned addition are avoided as a result of demand reductions in the peak as well as the off-peak season. An entry of 1.0 means that each unit of demand reduction in that season results in the total annualized cost being avoided; a zero entry means no costs are avoided.

**Figure 7**
**Seasonal Multipliers Sheet**

**Seasonal Multipliers for Planned Additions**

| | Peak | | | | | Off-Peak | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GW # 1 | Reservoir North | Pipeline North | WTP B | Pipeline South | GW # 1 | Reservoir North | Pipeline North | WTP B | Pipeline South |
| | *2015* | *2010* | *2011* | *2024* | *2024* | *2015* | *2010* | *2011* | *2024* | *2024* |
| Years | | | | | | | | | | |
| 2005 to 2009 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 to 2014 | 1.00 | 1.00 | 0.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 to 2019 | 1.00 | 1.00 | 0.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 to 2024 | 1.00 | 1.00 | 0.70 | 1.00 | 1.00 | 0.00 | 0.60 | 0.00 | 0.00 | 0.00 |
| 2025 to 2029 | 1.00 | 1.00 | 0.70 | 1.00 | 1.00 | 0.00 | 0.60 | 0.00 | 0.00 | 0.00 |
| 2030 to 2034 | 1.00 | 1.00 | 0.70 | 1.00 | 1.00 | 0.00 | 0.70 | 0.00 | 0.00 | 0.00 |
| 2035 to 2039 | 1.00 | 1.00 | 0.70 | 1.00 | 1.00 | 0.00 | 0.70 | 0.00 | 0.00 | 0.00 |
| 2040 to 2044 | 1.00 | 1.00 | 0.70 | 1.00 | 1.00 | 0.00 | 0.70 | 0.00 | 0.00 | 0.00 |

In many if not most cases, the peak-season multiplier for all system additions will be 1 and, for systems without seasonal storage (surface water or groundwater), the off-peak-season multiplier will be zero. However, for systems with seasonal storage, the off-peak-season multiplier may be non-zero. Other system features which may result in a non-zero off-peak seasonal multiplier include water rights, contractual provisions, or physical limitations (e.g. annual groundwater basin safe yields). The off-peak-season multiplier indicates the expected proportion of off-peak-season demand reduction that will turn into an increase in peak-season supply,[29] which in turn would reduce the need for the system addition.

As is the case with the on-margin probabilities, these multipliers may also signal geographic limitations. Such limitations can be reflected by reducing seasonal multipliers below what they would otherwise have been.

[29] It is likely that these proportions will vary under differing hydrologic, weather, or other conditions. In such cases, the user may, if desired, utilize the optional condition-specific multiplier sheets described below.

While the use of the entries in this table is very different from the 'On-Margin Probabilities' matrix discussed above, many of the same observations apply. Thus, in addition to varying by season, they may also vary over time.

<u>Beginning with the on-line date, blank entries in this table are assumed to be the default values of 1.0 in the peak season and zero in the off-peak season.</u>

The estimation process for these multipliers will also be very utility-specific, and the complexity of the process will vary by utility. Once again, system simulation models, if available, can be very useful. Those utilities that do not have such models must use the best collective knowledge and expertise of planning and operations staff to populate this matrix.

As is the case for the on-margin probabilities used in the short-term avoided cost calculation, the model includes three optional worksheets that may be used to represent differing hydrologic, weather, or other conditions, and a sheet which computes the weighted average of the condition-specific seasonal multipliers. The weights at the top of the condition sheets must add to 100%. *Use of these sheets is solely at the discretion of the user. If the user chooses to use these sheets, he/she must manually copy or export the weighted average results to the 'Seasonal Multipliers' worksheet.*

Once again, the user is encouraged to use the model to perform sensitivity tests—changing values of these multipliers to test the sensitivity of the results.

## LONG-RUN AVOIDED COSTS

This sheet presents the results of the long-run avoided cost calculation. <u>No user inputs are permitted on this sheet.</u>

The calculation is divided into several steps. Note that all intermediate calculations use nominal dollars. The final results are expressed both in nominal and real (cost reference year) dollars.

### Potential Avoided Costs in On-Line Year (see Figure 8a)

**Annualized Cost of Planned Addition.** For each planned addition, the model calculates the annualized cost of the capital investment over the entire planning period. The annualized capital cost is based on the interest rate and capital cost provided by the user. The annual fixed O&M cost is based on the real-dollar costs and inflation rate provided by the user.

**Annualized Deferred Cost**. For each deferrable planned addition, the model then calculates the annualized cost of both the capital investment and the fixed O&M cost in the planned on-line year, assuming the investment is deferred for a period corresponding to the peak-season 1 mgd deferral periods calculated on the Demands worksheet (see above).

**Annualized Downsized Cost**. For each planned addition that is subject to downsizing, the model calculates the annualized cost of both the capital investment and the fixed O&M cost in the planned on-line year, assuming the investment is downsized as described above.

**Potential Avoided Cost**. The potential annual avoided cost is the difference between the annualized cost of the planned addition and the annual cost of either the deferred or the downsized addition.

**Figure 8a**

| Potential Avoided Costs in On-Line Year | | | | | |
|---|---|---|---|---|---|
| | On-line Year | Annualized Cost of Planned Addition | Annualized Deferred Cost (with 1 mgd Demand Reduction) | Annualized Downsized Cost (with 1 mgd Demand Reduction) | Potential Avoided Cost |
| | | Nominal $ (Millions) | Nominal $ (Millions) | Nominal $ (Millions) | ($ million/mgd) |
| **Capital** | | | | | |
| GW # 1 | 2015 | $1.174 | $0.000 | $1.080 | $0.0939 |
| Reservoir North | 2010 | $10.117 | $9.984 | $0.000 | $0.1326 |
| Pipeline North | 2011 | $2.084 | $2.031 | $0.000 | $0.0532 |
| WTP B | 2024 | $0.767 | $0.000 | $0.614 | $0.1534 |
| Pipeline South | 2024 | $7.672 | $7.326 | $0.000 | $0.3460 |
| **Fixed O&M** | | Nominal $ (Millions) | Nominal $ (Millions) | Nominal $ (Millions) | ($ million/mgd) |
| GW # 1 | 2015 | $0.000 | $0.000 | $0.000 | $0.0000 |
| Reservoir North | 2010 | $0.116 | $0.115 | $0.000 | $0.0015 |
| Pipeline North | 2011 | $0.000 | $0.000 | $0.000 | $0.0000 |
| WTP B | 2024 | $0.044 | $0.000 | $0.035 | $0.0440 |
| Pipeline South | 2024 | $0.000 | $0.000 | $0.000 | $0.0000 |

## Avoided Capital and Fixed O&M Costs (see Figure 8b)

Based on these potential avoided costs and the period multipliers, the model then calculates the annualized avoided capital and fixed O&M costs for each planned addition for each season and each year of the planning period. As described above, the annualized avoided capital and fixed O&M costs associated with a particular addition begin to be incurred in that addition's on-line year. The avoided capital costs persist over the Financing Term specified on the Planned Additions sheet, while the avoided Fixed O&M

costs continue to the end of the planning period. In each year, the total long-run avoided cost (either capital or fixed O&M) is the sum of the annualized avoided costs for that year associated with all planned additions. For any year, some or all of these components will be zero, if the year either precedes all on-line dates (for both capital and fixed O&M) or is beyond all financing terms (capital only).

**Figure 8b**
**Avoided Capital and Fixed O&M Costs**

| Avoided Capital Costs by Season Nominal Dollars | | | Avoided Fixed O&M Costs by Season Nominal Dollars | | |
|---|---|---|---|---|---|
| | Peak ($ million/mgd) | Off-Peak ($ million/mgd) | | Peak ($ million/mgd) | Off-Peak ($ million/mgd) |
| 2005 | $0.0000 | $0.0000 | 2005 | $0.0000 | $0.0000 |
| 2006 | $0.0000 | $0.0000 | 2006 | $0.0000 | $0.0000 |
| 2007 | $0.0000 | $0.0000 | 2007 | $0.0000 | $0.0000 |
| 2008 | $0.0000 | $0.0000 | 2008 | $0.0000 | $0.0000 |
| 2009 | $0.0000 | $0.0000 | 2009 | $0.0000 | $0.0000 |
| 2010 | $0.1326 | $0.0000 | 2010 | $0.0015 | $0.0000 |
| 2011 | $0.1699 | $0.0000 | 2011 | $0.0016 | $0.0000 |
| 2012 | $0.1699 | $0.0000 | 2012 | $0.0016 | $0.0000 |
| 2013 | $0.1699 | $0.0000 | 2013 | $0.0017 | $0.0000 |
| 2014 | $0.1699 | $0.0000 | 2014 | $0.0017 | $0.0000 |
| 2015 | $0.2638 | $0.0000 | 2015 | $0.0018 | $0.0000 |
| 2016 | $0.2638 | $0.0000 | 2016 | $0.0018 | $0.0000 |
| 2017 | $0.2638 | $0.0000 | 2017 | $0.0019 | $0.0000 |
| 2018 | $0.2638 | $0.0000 | 2018 | $0.0019 | $0.0000 |
| 2019 | $0.2638 | $0.0000 | 2019 | $0.0020 | $0.0000 |
| 2020 | $0.2638 | $0.0796 | 2020 | $0.0020 | $0.0010 |
| 2021 | $0.2638 | $0.0796 | 2021 | $0.0021 | $0.0010 |
| 2022 | $0.2638 | $0.0796 | 2022 | $0.0022 | $0.0010 |
| 2023 | $0.2638 | $0.0796 | 2023 | $0.0022 | $0.0010 |
| 2024 | $0.7632 | $0.0796 | 2024 | $0.0463 | $0.0010 |
| 2025 | $0.7632 | $0.0796 | 2025 | $0.0477 | $0.0011 |
| 2026 | $0.7632 | $0.0796 | 2026 | $0.0491 | $0.0011 |
| 2027 | $0.7632 | $0.0796 | 2027 | $0.0506 | $0.0011 |
| 2028 | $0.7632 | $0.0796 | 2028 | $0.0522 | $0.0011 |
| 2029 | $0.7632 | $0.0796 | 2029 | $0.0537 | $0.0011 |
| 2030 | $0.6306 | $0.0000 | 2030 | $0.0554 | $0.0013 |
| 2031 | $0.5933 | $0.0000 | 2031 | $0.0570 | $0.0013 |
| 2032 | $0.5933 | $0.0000 | 2032 | $0.0588 | $0.0013 |
| 2033 | $0.5933 | $0.0000 | 2033 | $0.0605 | $0.0013 |
| 2034 | $0.5933 | $0.0000 | 2034 | $0.0624 | $0.0014 |
| 2035 | $0.4994 | $0.0000 | 2035 | $0.0642 | $0.0014 |
| 2036 | $0.4994 | $0.0000 | 2036 | $0.0662 | $0.0014 |
| 2037 | $0.4994 | $0.0000 | 2037 | $0.0682 | $0.0014 |
| 2038 | $0.4994 | $0.0000 | 2038 | $0.0702 | $0.0014 |
| 2039 | $0.4994 | $0.0000 | 2039 | $0.0724 | $0.0014 |
| 2040 | $0.4994 | $0.0000 | 2040 | $0.0745 | $0.0014 |

**Total Long-Run Avoided Costs (see Figure 8c)**

Finally, the model adds the capital and fixed O&M components to calculate the total long-run avoided costs. The costs are converted to volumetric units based on the user-specified number of days in each season, and are expressed in both nominal and real dollars.

**Figure 8c**
**Total Long-Run Avoided Costs**

| Total Long-Run Avoided Costs by Season Nominal Dollars | Peak-Season ($ million/mgd) | Peak-Season ($/mg) | Off-Peak Season ($ million/mgd) | Off-Peak Season ($/mg) |
|---|---|---|---|---|
| 2005 | $0.0000 | $0 | $0.0000 | $0 |
| 2006 | $0.0000 | $0 | $0.0000 | $0 |
| 2007 | $0.0000 | $0 | $0.0000 | $0 |
| 2008 | $0.0000 | $0 | $0.0000 | $0 |
| 2009 | $0.0000 | $0 | $0.0000 | $0 |
| 2010 | $0.1341 | $877 | $0.0000 | $0 |
| 2011 | $0.1714 | $1,121 | $0.0000 | $0 |
| 2012 | $0.1715 | $1,121 | $0.0000 | $0 |
| 2013 | $0.1715 | $1,121 | $0.0000 | $0 |
| 2014 | $0.1716 | $1,121 | $0.0000 | $0 |
| 2015 | $0.2656 | $1,736 | $0.0000 | $0 |
| 2016 | $0.2656 | $1,736 | $0.0000 | $0 |
| 2017 | $0.2657 | $1,736 | $0.0000 | $0 |
| 2018 | $0.2657 | $1,737 | $0.0000 | $0 |
| 2019 | $0.2658 | $1,737 | $0.0000 | $0 |
| 2020 | $0.2658 | $1,737 | $0.0806 | $380 |
| 2021 | $0.2659 | $1,738 | $0.0806 | $380 |
| 2022 | $0.2660 | $1,738 | $0.0806 | $380 |
| 2023 | $0.2660 | $1,739 | $0.0806 | $380 |
| 2024 | $0.8095 | $5,291 | $0.0806 | $380 |
| 2025 | $0.8109 | $5,300 | $0.0806 | $380 |
| 2026 | $0.8124 | $5,310 | $0.0806 | $380 |
| 2027 | $0.8138 | $5,319 | $0.0806 | $380 |
| 2028 | $0.8154 | $5,329 | $0.0807 | $380 |
| 2029 | $0.8170 | $5,340 | $0.0807 | $380 |
| 2030 | $0.6860 | $4,483 | $0.0013 | $6 |
| 2031 | $0.6504 | $4,251 | $0.0013 | $6 |
| 2032 | $0.6521 | $4,262 | $0.0013 | $6 |
| 2033 | $0.6539 | $4,274 | $0.0013 | $6 |
| 2034 | $0.6557 | $4,286 | $0.0014 | $6 |
| 2035 | $0.5637 | $3,684 | $0.0014 | $6 |
| 2036 | $0.5656 | $3,697 | $0.0014 | $7 |
| 2037 | $0.5676 | $3,710 | $0.0014 | $7 |
| 2038 | $0.5697 | $3,723 | $0.0014 | $7 |
| 2039 | $0.5718 | $3,737 | $0.0014 | $7 |
| 2040 | $0.5740 | $3,751 | $0.0014 | $7 |

| Total Long-Run Avoided Costs by Season 2005 Dollars | Peak-Season ($ million/mgd) | Peak-Season ($/mg) | Off-Peak Season ($ million/mgd) | Off-Peak Season ($/mg) |
|---|---|---|---|---|
| 2005 | $0.0000 | $0 | $0.0000 | $0 |
| 2006 | $0.0000 | $0 | $0.0000 | $0 |
| 2007 | $0.0000 | $0 | $0.0000 | $0 |
| 2008 | $0.0000 | $0 | $0.0000 | $0 |
| 2009 | $0.0000 | $0 | $0.0000 | $0 |
| 2010 | $0.1215 | $794 | $0.0000 | $0 |
| 2011 | $0.1522 | $995 | $0.0000 | $0 |
| 2012 | $0.1493 | $976 | $0.0000 | $0 |
| 2013 | $0.1464 | $957 | $0.0000 | $0 |
| 2014 | $0.1436 | $938 | $0.0000 | $0 |
| 2015 | $0.2178 | $1,424 | $0.0000 | $0 |
| 2016 | $0.2136 | $1,396 | $0.0000 | $0 |
| 2017 | $0.2095 | $1,369 | $0.0000 | $0 |
| 2018 | $0.2054 | $1,343 | $0.0000 | $0 |
| 2019 | $0.2014 | $1,316 | $0.0000 | $0 |
| 2020 | $0.1975 | $1,291 | $0.0599 | $282 |
| 2021 | $0.1937 | $1,266 | $0.0587 | $277 |
| 2022 | $0.1899 | $1,241 | $0.0576 | $271 |
| 2023 | $0.1863 | $1,217 | $0.0564 | $266 |
| 2024 | $0.5557 | $3,632 | $0.0553 | $261 |
| 2025 | $0.5457 | $3,567 | $0.0543 | $256 |
| 2026 | $0.5360 | $3,503 | $0.0532 | $251 |
| 2027 | $0.5264 | $3,441 | $0.0522 | $246 |
| 2028 | $0.5171 | $3,380 | $0.0511 | $241 |
| 2029 | $0.5079 | $3,320 | $0.0502 | $237 |
| 2030 | $0.4181 | $2,733 | $0.0008 | $4 |
| 2031 | $0.3887 | $2,540 | $0.0008 | $4 |
| 2032 | $0.3820 | $2,497 | $0.0008 | $4 |
| 2033 | $0.3756 | $2,455 | $0.0008 | $4 |
| 2034 | $0.3692 | $2,413 | $0.0008 | $4 |
| 2035 | $0.3112 | $2,034 | $0.0008 | $4 |
| 2036 | $0.3061 | $2,001 | $0.0007 | $4 |
| 2037 | $0.3012 | $1,969 | $0.0007 | $3 |
| 2038 | $0.2964 | $1,937 | $0.0007 | $3 |
| 2039 | $0.2916 | $1,906 | $0.0007 | $3 |
| 2040 | $0.2870 | $1,876 | $0.0007 | $3 |

**TOTAL DIRECT UTILITY AVOIDED COSTS (SEE FIGURE 9)**

On this sheet, the short-run and long-run avoided costs are added to obtain the total seasonal avoided supply costs by year, expressed both in real and nominal dollars.

<u>No user inputs are permitted on this worksheet.</u>

## Figure 9
## Total Direct Utility Avoided Costs Sheet

**Total Direct Utility Avoided Costs: Nominal Dollars**
($/mg)

| Year | Peak Season | | | Off-Peak Season | | |
|---|---|---|---|---|---|---|
| | Short-Run | Long-Run | Total | Short-Run | Long-Run | Total |
| 2007 | $254 | $0 | $254 | $251 | $0 | $251 |
| 2008 | $261 | $0 | $261 | $258 | $0 | $258 |
| 2009 | $268 | $0 | $268 | $265 | $0 | $265 |
| 2010 | $275 | $0 | $275 | $273 | $0 | $273 |
| 2011 | $283 | $0 | $283 | $280 | $0 | $280 |
| 2012 | $305 | $1,040 | $1,345 | $297 | $0 | $297 |
| 2013 | $314 | $1,040 | $1,354 | $306 | $0 | $306 |
| 2014 | $322 | $1,041 | $1,363 | $314 | $0 | $314 |
| 2015 | $331 | $1,655 | $1,986 | $323 | $0 | $323 |
| 2016 | $340 | $1,655 | $1,996 | $332 | $0 | $332 |
| 2017 | $404 | $1,656 | $2,059 | $359 | $0 | $359 |
| 2018 | $415 | $1,656 | $2,071 | $369 | $0 | $369 |
| 2019 | $426 | $1,656 | $2,083 | $379 | $0 | $379 |
| 2020 | $438 | $1,657 | $2,095 | $389 | $0 | $389 |
| 2021 | $451 | $1,657 | $2,108 | $400 | $0 | $400 |
| 2022 | $457 | $1,658 | $2,115 | $411 | $395 | $807 |
| 2023 | $470 | $1,658 | $2,128 | $423 | $395 | $818 |
| 2024 | $483 | $5,232 | $5,716 | $435 | $396 | $830 |
| 2025 | $497 | $5,242 | $5,738 | $447 | $396 | $842 |
| 2026 | $511 | $5,251 | $5,762 | $459 | $396 | $855 |
| 2027 | $555 | $5,261 | $5,816 | $468 | $396 | $864 |
| 2028 | $571 | $5,271 | $5,841 | $482 | $396 | $877 |
| 2029 | $587 | $5,281 | $5,868 | $495 | $396 | $891 |
| 2030 | $603 | $4,390 | $4,994 | $509 | $5 | $514 |
| 2031 | $620 | $4,274 | $4,894 | $523 | $6 | $529 |
| 2032 | $641 | $4,285 | $4,926 | $534 | $7 | $540 |
| 2033 | $659 | $4,297 | $4,956 | $549 | $7 | $555 |
| 2034 | $678 | $4,309 | $4,986 | $564 | $7 | $571 |
| 2035 | $697 | $3,707 | $4,404 | $580 | $7 | $587 |
| 2036 | $717 | $3,720 | $4,436 | $596 | $7 | $603 |
| 2037 | $737 | $3,733 | $4,470 | $613 | $7 | $620 |
| 2038 | $758 | $3,746 | $4,504 | $630 | $7 | $637 |
| 2039 | $779 | $3,760 | $4,540 | $648 | $7 | $655 |
| 2040 | $802 | $3,775 | $4,576 | $666 | $7 | $673 |

**Total Direct Utility Avoided Costs: 2005 Dollars**
($/mg)

| Year | Peak Season | | | Off-Peak Season | | |
|---|---|---|---|---|---|---|
| | Short-Run | Long-Run | Total | Short-Run | Long-Run | Total |
| 2007 | $244 | $0 | $244 | $242 | $0 | $242 |
| 2008 | $246 | $0 | $246 | $243 | $0 | $243 |
| 2009 | $248 | $0 | $248 | $245 | $0 | $245 |
| 2010 | $250 | $0 | $250 | $247 | $0 | $247 |
| 2011 | $251 | $0 | $251 | $249 | $0 | $249 |
| 2012 | $266 | $905 | $1,171 | $259 | $0 | $259 |
| 2013 | $268 | $888 | $1,156 | $261 | $0 | $261 |
| 2014 | $270 | $871 | $1,140 | $263 | $0 | $263 |
| 2015 | $272 | $1,358 | $1,629 | $265 | $0 | $265 |
| 2016 | $274 | $1,331 | $1,605 | $267 | $0 | $267 |
| 2017 | $318 | $1,305 | $1,624 | $283 | $0 | $283 |
| 2018 | $321 | $1,280 | $1,601 | $285 | $0 | $285 |
| 2019 | $323 | $1,255 | $1,579 | $287 | $0 | $287 |
| 2020 | $326 | $1,231 | $1,557 | $289 | $0 | $289 |
| 2021 | $328 | $1,207 | $1,535 | $292 | $0 | $292 |
| 2022 | $327 | $1,184 | $1,510 | $294 | $282 | $576 |
| 2023 | $329 | $1,161 | $1,490 | $296 | $277 | $573 |
| 2024 | $332 | $3,592 | $3,923 | $298 | $271 | $570 |
| 2025 | $334 | $3,527 | $3,862 | $301 | $266 | $567 |
| 2026 | $337 | $3,465 | $3,801 | $303 | $261 | $564 |
| 2027 | $359 | $3,403 | $3,762 | $303 | $256 | $559 |
| 2028 | $362 | $3,343 | $3,704 | $305 | $251 | $556 |
| 2029 | $365 | $3,283 | $3,648 | $308 | $246 | $554 |
| 2030 | $368 | $2,676 | $3,044 | $310 | $3 | $314 |
| 2031 | $371 | $2,554 | $2,925 | $313 | $3 | $316 |
| 2032 | $375 | $2,510 | $2,886 | $313 | $4 | $317 |
| 2033 | $378 | $2,468 | $2,846 | $315 | $4 | $319 |
| 2034 | $382 | $2,426 | $2,808 | $318 | $4 | $321 |
| 2035 | $385 | $2,047 | $2,431 | $320 | $4 | $324 |
| 2036 | $388 | $2,013 | $2,401 | $323 | $4 | $326 |
| 2037 | $391 | $1,981 | $2,372 | $325 | $4 | $329 |
| 2038 | $394 | $1,949 | $2,343 | $328 | $4 | $332 |
| 2039 | $398 | $1,918 | $2,315 | $331 | $4 | $334 |
| 2040 | $401 | $1,887 | $2,288 | $333 | $4 | $337 |

## AVOIDED COSTS CHARTS (SEE FIGURES 10A AND 10B)

These charts show the peak-season and off-peak season avoided costs for the entire analysis period, expressed in nominal and real dollars respectively.

**Figure 10A**

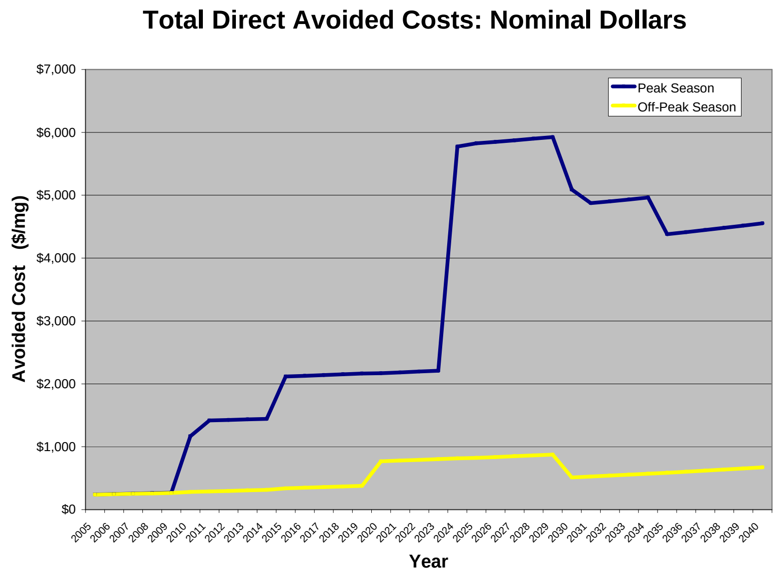
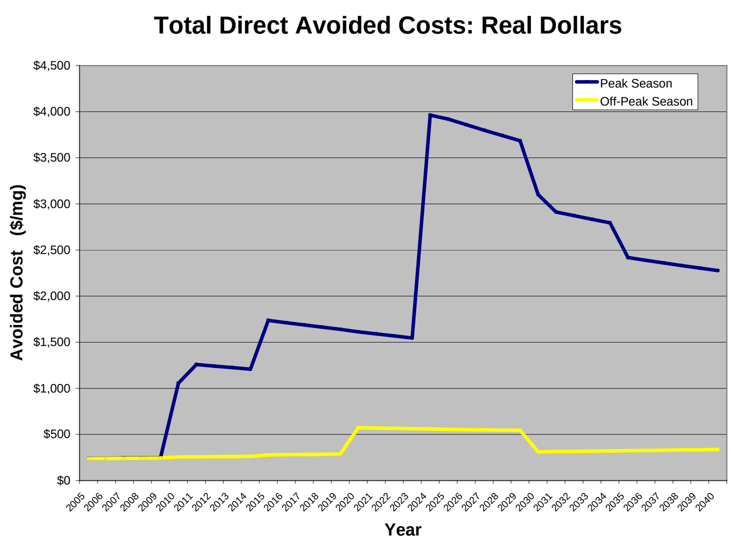



**FIGURE 10B**




## NON-WATER AVOIDED COSTS (SEE FIGURE 11)

On this sheet, the user may, if so desired, enter the names and magnitudes of up to three types of non-water-utility costs that are avoided (by other utilities or by customers) for each unit of water conserved, along with the real escalation rates for these avoided costs.

These avoided costs are in addition to the water utility's own short-run and long-run avoided costs that the model has calculated. Note that these entries are for the user's convenience only and do not affect any other model calculations. Also, unlike the avoided water supply costs, some of these components may be specific to particular conservation programs.

**WATER AND NON-WATER AVOIDED COSTS (SEE FIGURE 12)**

This final sheet arrays the water and non-water avoided costs, as well as the environmental costs from the CUWCC Environmental Benefits Model, all expressed in both nominal and real dollars. The column headings for each of the non-water avoided costs will match those entered by the user on the Non-Water Avoided Costs sheet. The only user inputs permitted on this worksheet are the environmental benefits, which may either be imported directly from the Environmental Benefits Model or entered manually.

**Figure 11**

**Non-Water Utility Avoided Costs**

| Type of Avoided Cost | Ref. Year Peak-Season Avoided Cost | Ref. Year Off-Peak-Season Avoided Cost | Annual Real Escalation Rates |
|---|---|---|---|
| | ($/mg) | ($/mg) | |
| Wastewater | $50 | $100 | 1.00% |
| Electric | $50 | $25 | 1.00% |
| Gas | $75 | $50 | 1.00% |

# Figure 12

**Combined Water and Non-Water Utility Avoided Costs: Nominal Dollars**

**($/mg)**

| Year | Peak Season | | | | | Off-Peak Season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Water | Type 1 | Type 2 | Type 3 | Environmental | Water | Type 1 | Type 2 | Type 3 | Environmental |
| 2005 | $241 | $50 | $50 | $75 | | $238 | $100 | $25 | $50 | |
| 2006 | $247 | $50 | $50 | $75 | | $245 | $100 | $25 | $50 | |
| 2007 | $254 | $50 | $50 | $75 | | $251 | $100 | $25 | $50 | |
| 2008 | $261 | $50 | $50 | $75 | | $258 | $100 | $25 | $50 | |
| 2009 | $268 | $50 | $50 | $75 | | $265 | $100 | $25 | $50 | |
| 2010 | $1,166 | $50 | $50 | $75 | | $282 | $100 | $25 | $50 | |
| 2011 | $1,418 | $50 | $50 | $75 | | $289 | $100 | $25 | $50 | |
| 2012 | $1,426 | $50 | $50 | $75 | | $297 | $100 | $25 | $50 | |
| 2013 | $1,435 | $50 | $50 | $75 | | $306 | $100 | $25 | $50 | |
| 2014 | $1,444 | $50 | $50 | $75 | | $314 | $100 | $25 | $50 | |
| 2015 | $2,118 | $50 | $50 | $75 | | $339 | $100 | $25 | $50 | |
| 2016 | $2,129 | $50 | $50 | $75 | | $349 | $100 | $25 | $50 | |
| 2017 | $2,140 | $50 | $50 | $75 | | $359 | $100 | $25 | $50 | |
| 2018 | $2,152 | $50 | $50 | $75 | | $369 | $100 | $25 | $50 | |
| 2019 | $2,164 | $50 | $50 | $75 | | $379 | $100 | $25 | $50 | |
| 2020 | $2,170 | $50 | $50 | $75 | | $769 | $100 | $25 | $50 | |
| 2021 | $2,183 | $50 | $50 | $75 | | $780 | $100 | $25 | $50 | |
| 2022 | $2,195 | $50 | $50 | $75 | | $792 | $100 | $25 | $50 | |
| 2023 | $2,209 | $50 | $50 | $75 | | $803 | $100 | $25 | $50 | |
| 2024 | $5,774 | $50 | $50 | $75 | | $815 | $100 | $25 | $50 | |
| 2025 | $5,825 | $50 | $50 | $75 | | $824 | $100 | $25 | $50 | |
| 2026 | $5,849 | $50 | $50 | $75 | | $836 | $100 | $25 | $50 | |
| 2027 | $5,874 | $50 | $50 | $75 | | $849 | $100 | $25 | $50 | |
| 2028 | $5,900 | $50 | $50 | $75 | | $862 | $100 | $25 | $50 | |
| 2029 | $5,926 | $50 | $50 | $75 | | $876 | $100 | $25 | $50 | |
| 2030 | $5,090 | $50 | $50 | $75 | | $511 | $100 | $25 | $50 | |
| 2031 | $4,874 | $50 | $50 | $75 | | $525 | $100 | $25 | $50 | |
| 2032 | $4,903 | $50 | $50 | $75 | | $540 | $100 | $25 | $50 | |
| 2033 | $4,933 | $50 | $50 | $75 | | $555 | $100 | $25 | $50 | |
| 2034 | $4,963 | $50 | $50 | $75 | | $571 | $100 | $25 | $50 | |
| 2035 | $4,381 | $50 | $50 | $75 | | $586 | $100 | $25 | $50 | |
| 2036 | $4,413 | $50 | $50 | $75 | | $603 | $100 | $25 | $50 | |
| 2037 | $4,447 | $50 | $50 | $75 | | $620 | $100 | $25 | $50 | |
| 2038 | $4,481 | $50 | $50 | $75 | | $637 | $100 | $25 | $50 | |
| 2039 | $4,517 | $50 | $50 | $75 | | $655 | $100 | $25 | $50 | |
| 2040 | $4,553 | $50 | $50 | $75 | | $673 | $100 | $25 | $50 | |

**Combined Water and Non-Water Utility Avoided Costs: 2005 Dollars**

**($/mg)**

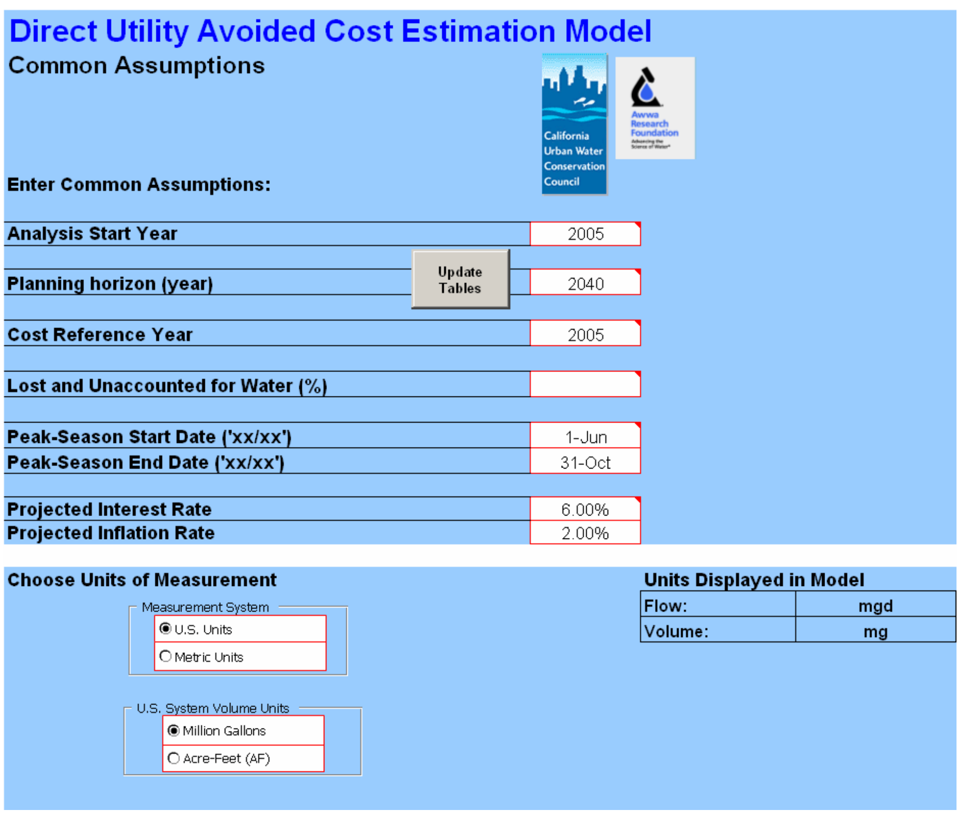
| Year | Peak Season | | | | | Off-Peak Season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Water | Type 1 | Type 2 | Type 3 | Environmental | Water | Type 1 | Type 2 | Type 3 | Environmental |
| 2005 | $241 | $50 | $50 | $75 | | $238 | $100 | $25 | $50 | |
| 2006 | $242 | $51 | $51 | $77 | | $240 | $102 | $26 | $51 | |
| 2007 | $244 | $52 | $52 | $78 | | $242 | $104 | $26 | $52 | |
| 2008 | $246 | $53 | $53 | $80 | | $243 | $106 | $27 | $53 | |
| 2009 | $248 | $54 | $54 | $81 | | $245 | $108 | $27 | $54 | |
| 2010 | $1,056 | $55 | $55 | $83 | | $255 | $110 | $28 | $55 | |
| 2011 | $1,259 | $56 | $56 | $84 | | $257 | $113 | $28 | $56 | |
| 2012 | $1,241 | $57 | $57 | $86 | | $259 | $115 | $29 | $57 | |
| 2013 | $1,225 | $59 | $59 | $88 | | $261 | $117 | $29 | $59 | |
| 2014 | $1,208 | $60 | $60 | $90 | | $263 | $120 | $30 | $60 | |
| 2015 | $1,737 | $61 | $61 | $91 | | $278 | $122 | $30 | $61 | |
| 2016 | $1,712 | $62 | $62 | $93 | | $281 | $124 | $31 | $62 | |
| 2017 | $1,687 | $63 | $63 | $95 | | $283 | $127 | $32 | $63 | |
| 2018 | $1,663 | $65 | $65 | $97 | | $285 | $129 | $32 | $65 | |
| 2019 | $1,640 | $66 | $66 | $99 | | $287 | $132 | $33 | $66 | |
| 2020 | $1,612 | $67 | $67 | $101 | | $572 | $135 | $34 | $67 | |
| 2021 | $1,590 | $69 | $69 | $103 | | $568 | $137 | $34 | $69 | |
| 2022 | $1,568 | $70 | $70 | $105 | | $565 | $140 | $35 | $70 | |
| 2023 | $1,546 | $71 | $71 | $107 | | $562 | $143 | $36 | $71 | |
| 2024 | $3,964 | $73 | $73 | $109 | | $559 | $146 | $36 | $73 | |
| 2025 | $3,920 | $74 | $74 | $111 | | $554 | $149 | $37 | $74 | |
| 2026 | $3,859 | $76 | $76 | $114 | | $552 | $152 | $38 | $76 | |
| 2027 | $3,800 | $77 | $77 | $116 | | $549 | $155 | $39 | $77 | |
| 2028 | $3,741 | $79 | $79 | $118 | | $547 | $158 | $39 | $79 | |
| 2029 | $3,685 | $80 | $80 | $121 | | $544 | $161 | $40 | $80 | |
| 2030 | $3,102 | $82 | $82 | $123 | | $312 | $164 | $41 | $82 | |
| 2031 | $2,913 | $84 | $84 | $126 | | $314 | $167 | $42 | $84 | |
| 2032 | $2,872 | $85 | $85 | $128 | | $316 | $171 | $43 | $85 | |
| 2033 | $2,833 | $87 | $87 | $131 | | $319 | $174 | $44 | $87 | |
| 2034 | $2,795 | $89 | $89 | $133 | | $321 | $178 | $44 | $89 | |
| 2035 | $2,419 | $91 | $91 | $136 | | $324 | $181 | $45 | $91 | |
| 2036 | $2,389 | $92 | $92 | $139 | | $326 | $185 | $46 | $92 | |
| 2037 | $2,360 | $94 | $94 | $141 | | $329 | $188 | $47 | $94 | |
| 2038 | $2,331 | $96 | $96 | $144 | | $331 | $192 | $48 | $96 | |
| 2039 | $2,304 | $98 | $98 | $147 | | $334 | $196 | $49 | $98 | |
| 2040 | $2,277 | $100 | $100 | $150 | | $337 | $200 | $50 | $100 | |

# APPENDIX B: CUWCC DIRECT UTILITY AVOIDED COST MODEL EXAMPLES

The following examples are intended to illustrate use of the CUWCC/AwwaRF Direct Utility Avoided Cost model. The examples show the effect of different supply and facility portfolios on implementation of the avoided cost calculations. In each case, the assumed current and planned system configuration is described and then the manner in which the model would analyze this case is discussed. For each example, full or partial model input and output screens are shown. The examples are increasing order of complexity, beginning with very simple cases and progressing to more involved circumstances.

All of the examples assume the same Common Assumptions, Demands, and Non-Water Utility Avoided Costs--shown in Figures A, B, and C respectively.

## Figure A


**Direct Utility Avoided Cost Estimation Model**

**Common Assumptions**

**Enter Common Assumptions:**

| | |
|---|---|
| Analysis Start Year | 2005 |
| Planning horizon (year) | 2040 |
| Cost Reference Year | 2005 |
| Lost and Unaccounted for Water (%) | |
| Peak-Season Start Date ('xx/xx') | 1-Jun |
| Peak-Season End Date ('xx/xx') | 31-Oct |
| Projected Interest Rate | 6.00% |
| Projected Inflation Rate | 2.00% |

Update Tables

**Choose Units of Measurement**

Measurement System

- (●) U.S. Units
- ( ) Metric Units

U.S. System Volume Units

- (●) Million Gallons
- ( ) Acre-Feet (AF)

**Units Displayed in Model**

| | |
|---|---|
| Flow: | mgd |
| Volume: | mg |

# Figure B

**Forecasted Demands**

Demand Data Entry Units: Flow

| Year | Seasonal Demand Peak (mgd) | Seasonal Demand Off-Peak (mgd) | Annual Demand Growth Peak-Season (mgd) | Annual Demand Growth Off-Peak Season (mgd) | Peak Season 1 mgd Deferral Periods (years) |
|---|---|---|---|---|---|
| 2005 | 200.0 | 100.0 | 4.0 | 2.0 | 0.250 |
| 2006 | 204.0 | 102.0 | 4.1 | 2.0 | 0.245 |
| 2007 | 208.1 | 104.0 | 4.2 | 2.1 | 0.240 |
| 2008 | 212.2 | 106.1 | 4.2 | 2.1 | 0.236 |
| 2009 | 216.5 | 108.2 | 4.3 | 2.2 | 0.231 |
| 2010 | 220.8 | 110.4 | 4.4 | 2.2 | 0.226 |
| 2011 | 225.2 | 112.6 | 2.3 | 1.1 | 0.444 |
| 2012 | 227.5 | 113.7 | 2.3 | 1.1 | 0.440 |
| 2013 | 229.8 | 114.9 | 2.3 | 1.1 | 0.435 |
| 2014 | 232.1 | 116.0 | 2.3 | 1.2 | 0.431 |
| 2015 | 234.4 | 117.2 | 2.3 | 1.2 | 0.427 |
| 2016 | 236.7 | 118.4 | 2.4 | 1.2 | 0.422 |
| 2017 | 239.1 | 119.5 | 2.4 | 1.2 | 0.418 |
| 2018 | 241.5 | 120.7 | 2.4 | 1.2 | 0.414 |
| 2019 | 243.9 | 121.9 | 2.4 | 1.2 | 0.410 |
| 2020 | 246.3 | 123.2 | 2.5 | 1.2 | 0.406 |
| 2021 | 248.8 | 124.4 | 1.2 | 0.6 | 0.804 |
| 2022 | 250.0 | 125.0 | 1.3 | 0.6 | 0.800 |
| 2023 | 251.3 | 125.6 | 1.3 | 0.6 | 0.796 |
| 2024 | 252.5 | 126.3 | 1.3 | 0.6 | 0.792 |
| 2025 | 253.8 | 126.9 | 1.3 | 0.6 | 0.788 |
| 2026 | 255.1 | 127.5 | 1.3 | 0.6 | 0.784 |
| 2027 | 256.4 | 128.2 | 1.3 | 0.6 | 0.780 |
| 2028 | 257.6 | 128.8 | 1.3 | 0.6 | 0.776 |
| 2029 | 258.9 | 129.5 | 1.3 | 0.6 | 0.772 |
| 2030 | 260.2 | 130.1 | 1.3 | 0.7 | 0.769 |
| 2031 | 261.5 | 130.8 | 1.3 | 0.7 | 0.765 |
| 2032 | 262.8 | 131.4 | 1.3 | 0.7 | 0.761 |
| 2033 | 264.1 | 132.1 | 1.3 | 0.7 | 0.757 |
| 2034 | 265.5 | 132.7 | 1.3 | 0.7 | 0.753 |
| 2035 | 266.8 | 133.4 | 1.3 | 0.7 | 0.750 |
| 2036 | 268.1 | 134.1 | 1.3 | 0.7 | 0.746 |
| 2037 | 269.5 | 134.7 | 1.3 | 0.7 | 0.742 |
| 2038 | 270.8 | 135.4 | 1.4 | 0.7 | 0.739 |
| 2039 | 272.2 | 136.1 | 1.4 | 0.7 | 0.735 |
| 2040 | 273.5 | 136.8 | 1.4 | 0.7 | 0.731 |

## Figure C

| Non-Water Utility Avoided Costs | | | |
|---|---|---|---|
| Type of Avoided Cost | Ref. Year Peak-Season Avoided Cost | Ref. Year Off-Peak-Season Avoided Cost | Annual Real Escalation Rates |
| | ($/mg) | ($/mg) | |
| Wastewater | $50 | $100 | 1.00% |
| Electric | $50 | $25 | 1.00% |
| Gas | $75 | $50 | 1.00% |

**EXAMPLE 1**

**Existing supply:** 1 Purchase

**Other current system components with variable operating costs:** None

**Planned system components:** None

In this case, the utility has a single current source of supply, which is a purchased treated supply. No new supplies are added over the planning period.

**Short Run Avoided Costs**. Assuming the variable portion of the price paid for the single purchased supply is currently $200 per million gallons, with a 2% annual real escalation rate, the *Variable Operating Costs* input sheet will look like Figure 1-1. Since there is only one source of supply, the on-margin probabilities for that source are 100% in both seasons, so the *On-Margin Probabilities* input sheet will look like Figure 1-2. (In this case, there is no need to use the conditional on-margin probabilities sheets.)

The short-run avoided costs are calculated by the model and shown on the *Short-Run Avoided Costs* output sheet. See Figure 1-3.

**Long-Run Avoided Costs**. Since there are no plans to add components to the system over the planning period, no entries need to be made on either the *Planned Additions* or *Seasonal Multipliers* sheets. The long-run avoided costs are zero.

**Total Direct Utility Avoided Costs**. As shown in Figure 1-4, since the long-run avoided costs are zero, the total direct avoided costs equal the short-run avoided costs.[30]

**Water and Non-Water Avoided Costs**. Figure 1-5 shows the final output screen, which displays the Direct Avoided Cost, along with the costs avoided by the non-water utilities (based on the user inputs shown in Figure C), as well as the environmental benefits, if any. (The environmental benefits may be imported from the CUWCC Environmental Benefits model.)

**EXAMPLE 2**

**Existing supply:**

1 local stream diversion

**Other current system components with variable operating costs:**

1 treatment plant

**Planned system components:** None

In this case, the utility has a single current source of supply, a local stream diversion, and a single treatment plant. No new system components are added over the planning period.

**Short Run Avoided Costs**. The stream diversion is assumed to have current variable power costs of $20 per million gallons with a 1% annual real escalation rate. The treatment plant is assumed to have current variable power costs of $150 per mg and current chemical costs of $75 per mg. The *Variable Operating Costs* input sheet will look like Figure 2-1. Since there is only one source of supply, the on-margin probabilities for

[30] To save space, versions of this sheet for subsequent examples will show only nominal dollars.

that source are 100% in both seasons, as are the on-margin probabilities of the treatment plant. The *On-Margin Probabilities* input sheet will look like Figure 2-2.

The short-run avoided costs are calculated by the model and shown on the *Short-Run Avoided Costs* output sheet. See Figure 2-3.

**Long-Run Avoided Costs**. Since there are no plans to add components to the system over the planning period, no entries need to be made on either the *Planned Additions* or *Seasonal Multipliers* sheets. The long-run avoided costs are zero.

**Total Direct Utility Avoided Costs**. As shown in Figure 2-4, since the long-run avoided costs are zero, the total direct avoided costs equal the short-run avoided costs.

**EXAMPLE 3**

**Existing supplies:**

1 local stream diversion

**Other current system components with variable operating costs:**

1 treatment plant

**Planned system components:**

1 local groundwater source in 2015 (Defer)

In this case, a groundwater source is added to the Example 2 configuration in 2015. The timing of this source can be deferred in response to demand reductions. No new treatment capacity is required.

**Short Run Avoided Costs**. The groundwater source is assumed to have current power costs of $100/mg. The *Variable Operating Costs* input sheet will look like Figure 3-1. Prior to 2015, there is only one source of supply; thus, the on-margin probabilities for the stream diversion are 100% in both seasons. Beginning in 2015, the groundwater source is expected to be the marginal source part of the time. The *On-Margin Probabilities* input sheet shown in Figure 3-2a illustrates error messages that the user will see if two common errors are made. In this case, the user has erroneously assigned a non-zero on-margin probability to the groundwater source in 2010, prior to its on-line date. In addition, the on-margin probabilities for the diversion and groundwater sources add to more than 100% in the 2015 off-peak season. These errors are corrected in Figure 3-2b.

The short-run avoided costs are calculated by the model and shown on the *Short-Run Avoided Costs* output sheet. See Figure 3-3.

**Long-Run Avoided Costs**. The new groundwater supply is sized at 10 mgd, and has a capital cost of $10 million. The *Planned Additions* input sheet is shown in Figure 3-4.

The utility system is such that the timing of the groundwater supply addition is able to be deferred only in response to reductions in peak-season demands. Off-peak season demand reductions will have no effect on the timing. Thus, the *Seasonal Multipliers* sheet, shown in Figure 3-5, has peak season multipliers for this supply of 1 and off-peak season multipliers of zero, beginning in the on-line year of 2015.

The resulting long-run avoided costs are shown in the *Long-Run Avoided Costs* sheet, the final portion of which is shown in Figure 3-6.

**Total Direct Utility Avoided Costs**. Figure 3-7 shows the *Total Avoided Costs* sheet, which adds the short-run and long-run avoided costs to compute the total seasonal avoided costs over the planning period.

**EXAMPLE 4**

**Existing supplies:**

1 local stream diversion

**Other current system components with variable operating costs:**

1 treatment plant

1 conveyance path group

**Planned system components:**

1 local groundwater source in 2015 (Defer)

This case modifies Example 3 by assuming a current conveyance path grouping with non-zero pumping cost. Specifically, the pumping cost for this group is $25 per million gallons. In other words, there is a set of conveyance paths for which the pumping costs cluster around $25 per mg.

In addition, this case illustrates the use of the optional conditional on-margin probability worksheets to reflect wet, average, and dry hydrologic years. It is assumed that such years occur with probabilities of 30%, 50%, and 20% respectively.

**Short Run Avoided Costs**. The *Variable Operating Costs* input sheet is shown in Figure 4-1. The values on the *On-Margin Probabilities* sheet are the weighted averages of the wet, average, and dry year probabilities shown on Figures 4-2a, 4-2b, and 4-2c respectively. Note that the wet year on-margin probabilities are higher for the stream diversion and lower for the more expensive groundwater source. The reverse is the case in dry conditions. The On-Margin Probabilities sheet, which is a weighted average of these three conditions, is shown in Figure 4-2d.

The short-run avoided costs are shown on the *Short-Run Avoided Costs* output sheet, Figure 4-3.

**Long-Run Avoided Costs**. Since the component to be added is identical to Example 3, the long-run avoided costs are identical to that case (see Figure 3-6).

**Total Direct Utility Avoided Costs.** The total avoided costs are shown in Figure 4-4. The accompanying chart is shown in Figure 4-5.

**EXAMPLE 5**

**Existing supplies:**

1 local stream diversion

**Other current system components with variable operating costs:**

1 treatment plant

1 conveyance path group

**Planned system components:**

1 local groundwater source in 2015 (Defer)

1 surface reservoir in 2010 (Defer)

1 transmission line in 2010 (Defer)

This case adds investments in a surface reservoir and a new transmission line in 2010 to the configuration of Example 4. It is assumed that the reservoir has no variable operating costs. Both of these new investments can be deferred in response to a demand reduction. In addition, the losses for the diversion and the groundwater source are expressed as component-specific losses. (The system loss rate on the Common Assumptions sheet is set to zero.) Finally, it is assumed that reducing production at the diversion project results in $10/mg in lost revenue from the generation of hydroelectric power.

**Short Run Avoided Costs**. The *Variable Operating Costs* input sheet is shown in Figure 5-1. The new transmission line results in a new conveyance path group with pumping costs around $50 per mg. Since the new reservoir has no variable operating costs, it need not appear on this sheet. However, note in Figure 5-2, the *On-Margin Probabilities* sheet, that the peak-season on-margin probabilities of the diversion and groundwater sources add to less than 100% beginning in 2010, due to the fact that the reservoir is the marginal source some of the time. The on-margin probabilities of the new conveyance path grouping are also shown on this sheet.

The short-run avoided costs are shown on the *Short-Run Avoided Costs* output sheet, Figure 5-3.

**Long-Run Avoided Costs**. The *Planned Additions* input sheet is shown in Figure 5-4. The new reservoir has a capital cost of $100 million, and a fixed annual operating and maintenance cost of $100,000. The new transmission line will cost $20 million.

Unlike the groundwater supply, the need for the reservoir is affected to some extent by off-peak-season demands. Thus, the *Seasonal Multipliers* sheet, Figure 5-5, includes non-zero off-peak-season multipliers for the reservoir. Note also that the peak-season multipliers for the transmission line are less than one, reflecting the fact that this line is geographically limited to serve only a portion of system demands.

The *Long Run Avoided Costs* and *Total Direct Utility Avoided Costs* output sheets for this case are shown in Figures 5-6 and 5-7 respectively.

**EXAMPLE 6**

**Existing supplies:**

1 local stream diversion

**Other current system components with variable operating costs:**

1 treatment plant

1 conveyance path group

**Planned system components:**

1 local groundwater source in 2015 (Downsize)

1 surface reservoir in 2010 (Defer)

1 transmission line in 2010 (Defer)

The only difference between this case and Example 5 is that the added groundwater supply is assumed to be subject to downsizing rather than deferral. The only input difference is therefore on the *Planned Additions* sheet, which is shown as Figure 6-1. The groundwater source is designated as subject to downsizing ('do'). As a result, the user may enter a 'downsizing factor', and must enter the size of the addition and indicate whether the size is expressed in flow or volumetric units. In this case, this addition has a Downsize Factor of 0.8, which means that the reduction in cost due to a demand reduction will be less than proportional. This supply is sized at 10 mgd.

The on-margin probabilities and seasonal multipliers are identical to those in Example 5.

The *Long Run Avoided Costs* and *Total Direct Utility Avoided Costs* output sheets for this case are shown in Figures 6-2, and 6-3 respectively.

**EXAMPLE 7**

**Existing supply:**

1 local stream diversion

**Other existing system components with variable operating costs:**

1 treatment plant

1 conveyance path group

**Planned system components:**

Transmission line added in 2010 (Defer)

Enlargement of existing surface reservoir in 2012 (Defer)

1 local groundwater source in 2015 (Downsize)

1 purchased source in 2024

1 transmission line in 2024 (Defer)

1 treatment plant in 2024 (Downsize)

This final example includes a larger number of current and added system components. It assumes a current configuration consisting of a stream diversion and a surface reservoir, as well as a treatment plant, and one conveyance path group with non-zero pumping costs. During the planning period, a new transmission line is added (creating a conveyance path group with pumping cost of around $50/mg), the capacity of the existing surface reservoir is enlarged and a new groundwater source is added. Later, an untreated purchased supply is added; a second treatment plant and a new transmission pipeline are added at the same time. The new pipeline itself has no pumping costs, so any additional conveyance paths created by the new pipeline become part of the existing conveyance path groups.

**Short Run Avoided Costs**. The *Variable Operating Cost* input sheet is shown in Figure 7-1. Note that only those existing and planned system components that have non-zero variable operating costs are included. Thus, the existing surface reservoir and its planned enlargement are not shown. The planned pipeline is also not shown because each of the new paths it creates are included in one of the existing conveyance path groups. The *On-Margin Probabilities* sheet is shown in Figure 7-2. The resulting *Short Run Avoided Costs* output sheet is shown in Figure 7-3.

**Long-Run Avoided Costs**. The *Planned Additions* sheet is shown in Figure 7-4. It shows all of the planned additions for which a capital investment is required. (Thus, the planned purchase is not included.) The *Seasonal Multipliers* sheet is shown in Figure 7-5, and the *Long-Run Avoided Costs* output sheet in Figure 7-6.

Figure 7-7 shows the *Total Utility Direct Avoided Costs* sheet for this final example. The accompanying chart is shown in Figure 7-8.

## Figure 1-1

| Number of Components? | | Variable Operating Costs | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Component Type | Component Name | Existing or Planned? | On-Line Year (for Planned) | Loss Rate | Power Costs (2005 dollars) | Chemical Costs (2005 dollars) | Purchase Costs (2005 dollars) | Other Costs (2005 dollars) | Revenues (2005 dollars) |
| | | | | | ($/mg) | ($/mg) | ($/mg) | ($/mg) | ($/mg) |
| Su | Purchase A | e | | | | | $200 | | |
| | | | Annual Real Escalation Rates: | | 1.00% | 0.00% | 2.00% | 0.00% | 0.00% |

## Figure 1-2

**System Components:**
**On-Margin Probabilities**

| Year | Season | | Purchase A |
|---|---|---|---|
| | | *On-line dates:* | |
| | | *Type:* | *Su* |
| 2005 to 2009 | Peak | | 100% |
| | Off-Peak | | 100% |
| 2010 to 2014 | Peak | | 100% |
| | Off-Peak | | 100% |
| 2015 to 2019 | Peak | | 100% |
| | Off-Peak | | 100% |
| 2020 to 2024 | Peak | | 100% |
| | Off-Peak | | 100% |
| 2025 to 2029 | Peak | | 100% |
| | Off-Peak | | 100% |
| 2030 to 2034 | Peak | | 100% |
| | Off-Peak | | 100% |
| 2035 to 2039 | Peak | | 100% |
| | Off-Peak | | 100% |
| 2040 to 2044 | Peak | | 100% |
| | Off-Peak | | 100% |

# Figure 1-3

## Short-Run Avoided Costs
## ($/mg)

**Annual Short-Run Avoided Costs by Season**
**Nominal Dollars**

| Year | Peak-Season | Off-Peak Season |
|---|---|---|
| 2005 | $200.00 | $200.00 |
| 2006 | $208.08 | $208.08 |
| 2007 | $216.49 | $216.49 |
| 2008 | $225.23 | $225.23 |
| 2009 | $234.33 | $234.33 |
| 2010 | $243.80 | $243.80 |
| 2011 | $253.65 | $253.65 |
| 2012 | $263.90 | $263.90 |
| 2013 | $274.56 | $274.56 |
| 2014 | $285.65 | $285.65 |
| 2015 | $297.19 | $297.19 |
| 2016 | $309.20 | $309.20 |
| 2017 | $321.69 | $321.69 |
| 2018 | $334.68 | $334.68 |
| 2019 | $348.20 | $348.20 |
| 2020 | $362.27 | $362.27 |
| 2021 | $376.91 | $376.91 |
| 2022 | $392.14 | $392.14 |
| 2023 | $407.98 | $407.98 |
| 2024 | $424.46 | $424.46 |
| 2025 | $441.61 | $441.61 |
| 2026 | $459.45 | $459.45 |
| 2027 | $478.01 | $478.01 |
| 2028 | $497.32 | $497.32 |
| 2029 | $517.41 | $517.41 |
| 2030 | $538.32 | $538.32 |
| 2031 | $560.07 | $560.07 |
| 2032 | $582.69 | $582.69 |
| 2033 | $606.23 | $606.23 |
| 2034 | $630.72 | $630.72 |
| 2035 | $656.21 | $656.21 |
| 2036 | $682.72 | $682.72 |
| 2037 | $710.30 | $710.30 |
| 2038 | $738.99 | $738.99 |
| 2039 | $768.85 | $768.85 |
| 2040 | $799.91 | $799.91 |

**Annual Short-Run Avoided Costs by Season**
**2005 Dollars**

| Year | Peak-Season | Off-Peak Season |
|---|---|---|
| 2005 | $200.00 | $200.00 |
| 2006 | $204.00 | $204.00 |
| 2007 | $208.08 | $208.08 |
| 2008 | $212.24 | $212.24 |
| 2009 | $216.49 | $216.49 |
| 2010 | $220.82 | $220.82 |
| 2011 | $225.23 | $225.23 |
| 2012 | $229.74 | $229.74 |
| 2013 | $234.33 | $234.33 |
| 2014 | $239.02 | $239.02 |
| 2015 | $243.80 | $243.80 |
| 2016 | $248.67 | $248.67 |
| 2017 | $253.65 | $253.65 |
| 2018 | $258.72 | $258.72 |
| 2019 | $263.90 | $263.90 |
| 2020 | $269.17 | $269.17 |
| 2021 | $274.56 | $274.56 |
| 2022 | $280.05 | $280.05 |
| 2023 | $285.65 | $285.65 |
| 2024 | $291.36 | $291.36 |
| 2025 | $297.19 | $297.19 |
| 2026 | $303.13 | $303.13 |
| 2027 | $309.20 | $309.20 |
| 2028 | $315.38 | $315.38 |
| 2029 | $321.69 | $321.69 |
| 2030 | $328.12 | $328.12 |
| 2031 | $334.68 | $334.68 |
| 2032 | $341.38 | $341.38 |
| 2033 | $348.20 | $348.20 |
| 2034 | $355.17 | $355.17 |
| 2035 | $362.27 | $362.27 |
| 2036 | $369.52 | $369.52 |
| 2037 | $376.91 | $376.91 |
| 2038 | $384.45 | $384.45 |
| 2039 | $392.14 | $392.14 |
| 2040 | $399.98 | $399.98 |

# Figure 1-4

**Total Direct Utility Avoided Costs: Nominal Dollars**
($/mg)

| Year | Peak Season | | | Off-Peak Season | | |
|---|---|---|---|---|---|---|
| | Short-Run | Long-Run | Total | Short-Run | Long-Run | Total |
| 2005 | $200 | $0 | $200 | $200 | $0 | $200 |
| 2006 | $208 | $0 | $208 | $208 | $0 | $208 |
| 2007 | $216 | $0 | $216 | $216 | $0 | $216 |
| 2008 | $225 | $0 | $225 | $225 | $0 | $225 |
| 2009 | $234 | $0 | $234 | $234 | $0 | $234 |
| 2010 | $244 | $0 | $244 | $244 | $0 | $244 |
| 2011 | $254 | $0 | $254 | $254 | $0 | $254 |
| 2012 | $264 | $0 | $264 | $264 | $0 | $264 |
| 2013 | $275 | $0 | $275 | $275 | $0 | $275 |
| 2014 | $286 | $0 | $286 | $286 | $0 | $286 |
| 2015 | $297 | $0 | $297 | $297 | $0 | $297 |
| 2016 | $309 | $0 | $309 | $309 | $0 | $309 |
| 2017 | $322 | $0 | $322 | $322 | $0 | $322 |
| 2018 | $335 | $0 | $335 | $335 | $0 | $335 |
| 2019 | $348 | $0 | $348 | $348 | $0 | $348 |
| 2020 | $362 | $0 | $362 | $362 | $0 | $362 |
| 2021 | $377 | $0 | $377 | $377 | $0 | $377 |
| 2022 | $392 | $0 | $392 | $392 | $0 | $392 |
| 2023 | $408 | $0 | $408 | $408 | $0 | $408 |
| 2024 | $424 | $0 | $424 | $424 | $0 | $424 |
| 2025 | $442 | $0 | $442 | $442 | $0 | $442 |
| 2026 | $459 | $0 | $459 | $459 | $0 | $459 |
| 2027 | $478 | $0 | $478 | $478 | $0 | $478 |
| 2028 | $497 | $0 | $497 | $497 | $0 | $497 |
| 2029 | $517 | $0 | $517 | $517 | $0 | $517 |
| 2030 | $538 | $0 | $538 | $538 | $0 | $538 |
| 2031 | $560 | $0 | $560 | $560 | $0 | $560 |
| 2032 | $583 | $0 | $583 | $583 | $0 | $583 |
| 2033 | $606 | $0 | $606 | $606 | $0 | $606 |
| 2034 | $631 | $0 | $631 | $631 | $0 | $631 |
| 2035 | $656 | $0 | $656 | $656 | $0 | $656 |
| 2036 | $683 | $0 | $683 | $683 | $0 | $683 |
| 2037 | $710 | $0 | $710 | $710 | $0 | $710 |
| 2038 | $739 | $0 | $739 | $739 | $0 | $739 |
| 2039 | $769 | $0 | $769 | $769 | $0 | $769 |
| 2040 | $800 | $0 | $800 | $800 | $0 | $800 |

**Total Direct Utility Avoided Costs: 2005 Dollars**
($/mg)

| Year | Peak Season | | | Off-Peak Season | | |
|---|---|---|---|---|---|---|
| | Short-Run | Long-Run | Total | Short-Run | Long-Run | Total |
| 2005 | $200 | $0 | $200 | $200 | $0 | $200 |
| 2006 | $204 | $0 | $204 | $204 | $0 | $204 |
| 2007 | $208 | $0 | $208 | $208 | $0 | $208 |
| 2008 | $212 | $0 | $212 | $212 | $0 | $212 |
| 2009 | $216 | $0 | $216 | $216 | $0 | $216 |
| 2010 | $221 | $0 | $221 | $221 | $0 | $221 |
| 2011 | $225 | $0 | $225 | $225 | $0 | $225 |
| 2012 | $230 | $0 | $230 | $230 | $0 | $230 |
| 2013 | $234 | $0 | $234 | $234 | $0 | $234 |
| 2014 | $239 | $0 | $239 | $239 | $0 | $239 |
| 2015 | $244 | $0 | $244 | $244 | $0 | $244 |
| 2016 | $249 | $0 | $249 | $249 | $0 | $249 |
| 2017 | $254 | $0 | $254 | $254 | $0 | $254 |
| 2018 | $259 | $0 | $259 | $259 | $0 | $259 |
| 2019 | $264 | $0 | $264 | $264 | $0 | $264 |
| 2020 | $269 | $0 | $269 | $269 | $0 | $269 |
| 2021 | $275 | $0 | $275 | $275 | $0 | $275 |
| 2022 | $280 | $0 | $280 | $280 | $0 | $280 |
| 2023 | $286 | $0 | $286 | $286 | $0 | $286 |
| 2024 | $291 | $0 | $291 | $291 | $0 | $291 |
| 2025 | $297 | $0 | $297 | $297 | $0 | $297 |
| 2026 | $303 | $0 | $303 | $303 | $0 | $303 |
| 2027 | $309 | $0 | $309 | $309 | $0 | $309 |
| 2028 | $315 | $0 | $315 | $315 | $0 | $315 |
| 2029 | $322 | $0 | $322 | $322 | $0 | $322 |
| 2030 | $328 | $0 | $328 | $328 | $0 | $328 |
| 2031 | $335 | $0 | $335 | $335 | $0 | $335 |
| 2032 | $341 | $0 | $341 | $341 | $0 | $341 |
| 2033 | $348 | $0 | $348 | $348 | $0 | $348 |
| 2034 | $355 | $0 | $355 | $355 | $0 | $355 |
| 2035 | $362 | $0 | $362 | $362 | $0 | $362 |
| 2036 | $370 | $0 | $370 | $370 | $0 | $370 |
| 2037 | $377 | $0 | $377 | $377 | $0 | $377 |
| 2038 | $384 | $0 | $384 | $384 | $0 | $384 |
| 2039 | $392 | $0 | $392 | $392 | $0 | $392 |
| 2040 | $400 | $0 | $400 | $400 | $0 | $400 |

# Figure 1-5

| Combined Water and Non-Water Utility Avoided Costs: Nominal Dollars ($/mg) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Peak Season | | | | | Off-Peak Season | | | | |
| | Water | Wastewater | Electric | Gas | Environmental | Water | Wastewater | Electric | Gas | Environmental |
| 2005 | $200 | $50 | $50 | $75 | | $200 | $100 | $25 | $50 | |
| 2006 | $208 | $51 | $51 | $76 | | $208 | $101 | $25 | $51 | |
| 2007 | $216 | $51 | $51 | $77 | | $216 | $102 | $26 | $51 | |
| 2008 | $225 | $52 | $52 | $77 | | $225 | $103 | $26 | $52 | |
| 2009 | $234 | $52 | $52 | $78 | | $234 | $104 | $26 | $52 | |
| 2010 | $244 | $53 | $53 | $79 | | $244 | $105 | $26 | $53 | |
| 2011 | $254 | $53 | $53 | $80 | | $254 | $106 | $27 | $53 | |
| 2012 | $264 | $54 | $54 | $80 | | $264 | $107 | $27 | $54 | |
| 2013 | $275 | $54 | $54 | $81 | | $275 | $108 | $27 | $54 | |
| 2014 | $286 | $55 | $55 | $82 | | $286 | $109 | $27 | $55 | |
| 2015 | $297 | $55 | $55 | $83 | | $297 | $110 | $28 | $55 | |
| 2016 | $309 | $56 | $56 | $84 | | $309 | $112 | $28 | $56 | |
| 2017 | $322 | $56 | $56 | $85 | | $322 | $113 | $28 | $56 | |
| 2018 | $335 | $57 | $57 | $85 | | $335 | $114 | $28 | $57 | |
| 2019 | $348 | $57 | $57 | $86 | | $348 | $115 | $29 | $57 | |
| 2020 | $362 | $58 | $58 | $87 | | $362 | $116 | $29 | $58 | |
| 2021 | $377 | $59 | $59 | $88 | | $377 | $117 | $29 | $59 | |
| 2022 | $392 | $59 | $59 | $89 | | $392 | $118 | $30 | $59 | |
| 2023 | $408 | $60 | $60 | $90 | | $408 | $120 | $30 | $60 | |
| 2024 | $424 | $60 | $60 | $91 | | $424 | $121 | $30 | $60 | |
| 2025 | $442 | $61 | $61 | $92 | | $442 | $122 | $31 | $61 | |
| 2026 | $459 | $62 | $62 | $92 | | $459 | $123 | $31 | $62 | |
| 2027 | $478 | $62 | $62 | $93 | | $478 | $124 | $31 | $62 | |
| 2028 | $497 | $63 | $63 | $94 | | $497 | $126 | $31 | $63 | |
| 2029 | $517 | $63 | $63 | $95 | | $517 | $127 | $32 | $63 | |
| 2030 | $538 | $64 | $64 | $96 | | $538 | $128 | $32 | $64 | |
| 2031 | $560 | $65 | $65 | $97 | | $560 | $130 | $32 | $65 | |
| 2032 | $583 | $65 | $65 | $98 | | $583 | $131 | $33 | $65 | |
| 2033 | $606 | $66 | $66 | $99 | | $606 | $132 | $33 | $66 | |
| 2034 | $631 | $67 | $67 | $100 | | $631 | $133 | $33 | $67 | |
| 2035 | $656 | $67 | $67 | $101 | | $656 | $135 | $34 | $67 | |
| 2036 | $683 | $68 | $68 | $102 | | $683 | $136 | $34 | $68 | |
| 2037 | $710 | $69 | $69 | $103 | | $710 | $137 | $34 | $69 | |
| 2038 | $739 | $69 | $69 | $104 | | $739 | $139 | $35 | $69 | |
| 2039 | $769 | $70 | $70 | $105 | | $769 | $140 | $35 | $70 | |
| 2040 | $800 | $71 | $71 | $106 | | $800 | $142 | $35 | $71 | |

## Figure 2-1

| Component Type | Component Name | Existing or Planned? | On-Line Year (for Planned) | Loss Rate | Ref. Year Power Costs | Ref. Year Chemical Costs | Ref. Year Purchase Costs | Ref. Year Other Costs | Ref. Year Revenues |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | ($/mg) | ($/mg) | ($/mg) | ($/mg) | ($/mg) |
| Su | Diversion A | e | | | $20 | | | | |
| T | WTP A | e | | | $150 | $75 | | | |
| | | | Annual Real Escalation Rates: | | 1.00% | 0.00% | 2.00% | 0.00% | 0.00% |

Number of Components?

Variable Operating Costs

## Figure 2-2

**System Components:**
**On-Margin Probabilities**

| Year | Season | | Diversion A | WTP A |
|---|---|---|---|---|
| | | *On-line dates:* | | |
| | | *Type:* | *Su* | *T* |
| 2005 to 2009 | Peak | | 100% | 100% |
| | Off-Peak | | 100% | 100% |
| 2010 to 2014 | Peak | | 100% | 100% |
| | Off-Peak | | 100% | 100% |
| 2015 to 2019 | Peak | | 100% | 100% |
| | Off-Peak | | 100% | 100% |
| 2020 to 2024 | Peak | | 100% | 100% |
| | Off-Peak | | 100% | 100% |
| 2025 to 2029 | Peak | | 100% | 100% |
| | Off-Peak | | 100% | 100% |
| 2030 to 2034 | Peak | | 100% | 100% |
| | Off-Peak | | 100% | 100% |
| 2035 to 2039 | Peak | | 100% | 100% |
| | Off-Peak | | 100% | 100% |
| 2040 to 2044 | Peak | | 100% | 100% |
| | Off-Peak | | 100% | 100% |

## Figure 2-3

### Short-Run Avoided Costs
### ($/mg)

| Annual Short-Run Avoided Costs by Season | | | Annual Short-Run Avoided Costs by Season | | |
|---|---|---|---|---|---|
| Nominal Dollars | | | 2005 Dollars | | |
| Year | Peak-Season | Off-Peak Season | Year | Peak-Season | Off-Peak Season |
| 2005 | $245.00 | $245.00 | 2005 | $245.00 | $245.00 |
| 2006 | $251.63 | $251.63 | 2006 | $246.70 | $246.70 |
| 2007 | $258.45 | $258.45 | 2007 | $248.42 | $248.42 |
| 2008 | $265.46 | $265.46 | 2008 | $250.15 | $250.15 |
| 2009 | $272.67 | $272.67 | 2009 | $251.90 | $251.90 |
| 2010 | $280.07 | $280.07 | 2010 | $253.67 | $253.67 |
| 2011 | $287.69 | $287.69 | 2011 | $255.46 | $255.46 |
| 2012 | $295.51 | $295.51 | 2012 | $257.26 | $257.26 |
| 2013 | $303.56 | $303.56 | 2013 | $259.09 | $259.09 |
| 2014 | $311.83 | $311.83 | 2014 | $260.93 | $260.93 |
| 2015 | $320.33 | $320.33 | 2015 | $262.79 | $262.79 |
| 2016 | $329.08 | $329.08 | 2016 | $264.66 | $264.66 |
| 2017 | $338.06 | $338.06 | 2017 | $266.56 | $266.56 |
| 2018 | $347.30 | $347.30 | 2018 | $268.48 | $268.48 |
| 2019 | $356.80 | $356.80 | 2019 | $270.41 | $270.41 |
| 2020 | $366.57 | $366.57 | 2020 | $272.36 | $272.36 |
| 2021 | $376.61 | $376.61 | 2021 | $274.34 | $274.34 |
| 2022 | $386.93 | $386.93 | 2022 | $276.33 | $276.33 |
| 2023 | $397.55 | $397.55 | 2023 | $278.35 | $278.35 |
| 2024 | $408.46 | $408.46 | 2024 | $280.38 | $280.38 |
| 2025 | $419.68 | $419.68 | 2025 | $282.43 | $282.43 |
| 2026 | $431.22 | $431.22 | 2026 | $284.51 | $284.51 |
| 2027 | $443.08 | $443.08 | 2027 | $286.60 | $286.60 |
| 2028 | $455.28 | $455.28 | 2028 | $288.72 | $288.72 |
| 2029 | $467.82 | $467.82 | 2029 | $290.85 | $290.85 |
| 2030 | $480.72 | $480.72 | 2030 | $293.01 | $293.01 |
| 2031 | $493.98 | $493.98 | 2031 | $295.19 | $295.19 |
| 2032 | $507.62 | $507.62 | 2032 | $297.40 | $297.40 |
| 2033 | $521.64 | $521.64 | 2033 | $299.62 | $299.62 |
| 2034 | $536.07 | $536.07 | 2034 | $301.87 | $301.87 |
| 2035 | $550.90 | $550.90 | 2035 | $304.13 | $304.13 |
| 2036 | $566.15 | $566.15 | 2036 | $306.43 | $306.43 |
| 2037 | $581.83 | $581.83 | 2037 | $308.74 | $308.74 |
| 2038 | $597.96 | $597.96 | 2038 | $311.08 | $311.08 |
| 2039 | $614.55 | $614.55 | 2039 | $313.44 | $313.44 |
| 2040 | $631.61 | $631.61 | 2040 | $315.82 | $315.82 |

## Figure 2-4

| Total Direct Utility Avoided Costs: Nominal Dollars ($/mg) | | | | | | |
|---|---|---|---|---|---|---|
| Year | Peak Season | | | Off-Peak Season | | |
| | Short-Run | Long-Run | Total | Short-Run | Long-Run | Total |
| 2005 | $245 | $0 | **$245** | $245 | $0 | **$245** |
| 2006 | $252 | $0 | **$252** | $252 | $0 | **$252** |
| 2007 | $258 | $0 | **$258** | $258 | $0 | **$258** |
| 2008 | $265 | $0 | **$265** | $265 | $0 | **$265** |
| 2009 | $273 | $0 | **$273** | $273 | $0 | **$273** |
| 2010 | $280 | $0 | **$280** | $280 | $0 | **$280** |
| 2011 | $288 | $0 | **$288** | $288 | $0 | **$288** |
| 2012 | $296 | $0 | **$296** | $296 | $0 | **$296** |
| 2013 | $304 | $0 | **$304** | $304 | $0 | **$304** |
| 2014 | $312 | $0 | **$312** | $312 | $0 | **$312** |
| 2015 | $320 | $0 | **$320** | $320 | $0 | **$320** |
| 2016 | $329 | $0 | **$329** | $329 | $0 | **$329** |
| 2017 | $338 | $0 | **$338** | $338 | $0 | **$338** |
| 2018 | $347 | $0 | **$347** | $347 | $0 | **$347** |
| 2019 | $357 | $0 | **$357** | $357 | $0 | **$357** |
| 2020 | $367 | $0 | **$367** | $367 | $0 | **$367** |
| 2021 | $377 | $0 | **$377** | $377 | $0 | **$377** |
| 2022 | $387 | $0 | **$387** | $387 | $0 | **$387** |
| 2023 | $398 | $0 | **$398** | $398 | $0 | **$398** |
| 2024 | $408 | $0 | **$408** | $408 | $0 | **$408** |
| 2025 | $420 | $0 | **$420** | $420 | $0 | **$420** |
| 2026 | $431 | $0 | **$431** | $431 | $0 | **$431** |
| 2027 | $443 | $0 | **$443** | $443 | $0 | **$443** |
| 2028 | $455 | $0 | **$455** | $455 | $0 | **$455** |
| 2029 | $468 | $0 | **$468** | $468 | $0 | **$468** |
| 2030 | $481 | $0 | **$481** | $481 | $0 | **$481** |
| 2031 | $494 | $0 | **$494** | $494 | $0 | **$494** |
| 2032 | $508 | $0 | **$508** | $508 | $0 | **$508** |
| 2033 | $522 | $0 | **$522** | $522 | $0 | **$522** |
| 2034 | $536 | $0 | **$536** | $536 | $0 | **$536** |
| 2035 | $551 | $0 | **$551** | $551 | $0 | **$551** |
| 2036 | $566 | $0 | **$566** | $566 | $0 | **$566** |
| 2037 | $582 | $0 | **$582** | $582 | $0 | **$582** |
| 2038 | $598 | $0 | **$598** | $598 | $0 | **$598** |
| 2039 | $615 | $0 | **$615** | $615 | $0 | **$615** |
| 2040 | $632 | $0 | **$632** | $632 | $0 | **$632** |

## Figure 3-1

**Variable Operating Costs**

**Number of Components?**

| Component Type | Component Name | Existing or Planned? | On-Line Year (for Planned) | Loss Rate | Ref. Year Power Costs | Ref. Year Chemical Costs | Ref. Year Purchase Costs | Ref. Year Other Costs | Ref. Year Revenues |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | ($/mg) | ($/mg) | ($/mg) | ($/mg) | |
| Su | Diversion A | e | | | $20 | | | | |
| T | WTP A | e | | | $150 | $75 | | | |
| Su | GW #1 | p | 2015 | | $100 | | | | |
| | | | Annual Real Escalation Rates: | | 1.00% | 0.00% | 2.00% | 0.00% | 0.00% |

## Figure 3-2a

**System Components:**
**On-Margin Probabilities**

| | | | Diversion A | WTP A | GW #1 |
|---|---|---|---|---|---|
| | | *On-line dates:* | | | *2015* |
| | | | | | Error: Must be Zero Before On-Line Date |
| Year | Season | *Type:* | *Su* | *T* | *Su* |
| 2005 | Peak | | 100% | 100% | 0% |
| to 2009 | Off-Peak | | 100% | 100% | 0% |
| 2010 | Peak | Category >100% | 100% | 100% | 30% |
| to 2014 | Off-Peak | | 100% | 100% | 0% |
| 2015 | Peak | | 70% | 100% | 30% |
| to 2019 | Off-Peak | Category >100% | 100% | 100% | 10% |
| 2020 | Peak | | 70% | 100% | 30% |
| to 2024 | Off-Peak | | 90% | 100% | 10% |
| 2025 | Peak | | 70% | 100% | 30% |
| to 2029 | Off-Peak | | 90% | 100% | 10% |
| 2030 | Peak | | 65% | 100% | 35% |
| to 2034 | Off-Peak | | 85% | 100% | 15% |
| 2035 | Peak | | 65% | 100% | 35% |
| to 2039 | Off-Peak | | 85% | 100% | 15% |
| 2040 | Peak | | 60% | 100% | 40% |
| to 2044 | Off-Peak | | 80% | 100% | 20% |

## Figure 3-2b

**System Components:**
**On-Margin Probabilities**

| Year | Season | | Diversion A | WTP A | GW #1 |
|---|---|---|---|---|---|
| | | *On-line dates:* | | | *2015* |
| **Year** | **Season** | ***Type:*** | *Su* | *T* | *Su* |
| 2005 | Peak | | 100% | 100% | 0% |
| to 2009 | Off-Peak | | 100% | 100% | 0% |
| 2010 | Peak | | 100% | 100% | 0% |
| to 2014 | Off-Peak | | 100% | 100% | 0% |
| 2015 | Peak | | 70% | 100% | 30% |
| to 2019 | Off-Peak | | 90% | 100% | 10% |
| 2020 | Peak | | 70% | 100% | 30% |
| to 2024 | Off-Peak | | 90% | 100% | 10% |
| 2025 | Peak | | 70% | 100% | 30% |
| to 2029 | Off-Peak | | 90% | 100% | 10% |
| 2030 | Peak | | 65% | 100% | 35% |
| to 2034 | Off-Peak | | 85% | 100% | 15% |
| 2035 | Peak | | 65% | 100% | 35% |
| to 2039 | Off-Peak | | 85% | 100% | 15% |
| 2040 | Peak | | 60% | 100% | 40% |
| to 2044 | Off-Peak | | 80% | 100% | 20% |

## Figure 3-3

### Short-Run Avoided Costs ($/mg)

| Annual Short-Run Avoided Costs by Season<br>Nominal Dollars | | | Annual Short-Run Avoided Costs by Season<br>2005 Dollars | | |
|---|---|---|---|---|---|
| Year | Peak-Season | Off-Peak Season | Year | Peak-Season | Off-Peak Season |
| 2005 | $245.00 | $245.00 | 2005 | $245.00 | $245.00 |
| 2006 | $251.63 | $251.63 | 2006 | $246.70 | $246.70 |
| 2007 | $258.45 | $258.45 | 2007 | $248.42 | $248.42 |
| 2008 | $265.46 | $265.46 | 2008 | $250.15 | $250.15 |
| 2009 | $272.67 | $272.67 | 2009 | $251.90 | $251.90 |
| 2010 | $280.07 | $280.07 | 2010 | $253.67 | $253.67 |
| 2011 | $287.69 | $287.69 | 2011 | $255.46 | $255.46 |
| 2012 | $295.51 | $295.51 | 2012 | $257.26 | $257.26 |
| 2013 | $303.56 | $303.56 | 2013 | $259.09 | $259.09 |
| 2014 | $311.83 | $311.83 | 2014 | $260.93 | $260.93 |
| 2015 | $352.65 | $331.11 | 2015 | $289.30 | $271.62 |
| 2016 | $362.37 | $340.17 | 2016 | $291.44 | $273.59 |
| 2017 | $372.36 | $349.50 | 2017 | $293.60 | $275.57 |
| 2018 | $382.64 | $359.08 | 2018 | $295.79 | $277.58 |
| 2019 | $393.20 | $368.93 | 2019 | $298.00 | $279.61 |
| 2020 | $404.07 | $379.07 | 2020 | $300.23 | $281.65 |
| 2021 | $415.24 | $389.49 | 2021 | $302.48 | $283.72 |
| 2022 | $426.73 | $400.20 | 2022 | $304.76 | $285.81 |
| 2023 | $438.55 | $411.21 | 2023 | $307.05 | $287.91 |
| 2024 | $450.70 | $422.54 | 2024 | $309.37 | $290.04 |
| 2025 | $463.19 | $434.18 | 2025 | $311.72 | $292.19 |
| 2026 | $476.05 | $446.16 | 2026 | $314.08 | $294.37 |
| 2027 | $489.26 | $458.47 | 2027 | $316.47 | $296.56 |
| 2028 | $502.86 | $471.14 | 2028 | $318.89 | $298.78 |
| 2029 | $516.84 | $484.16 | 2029 | $321.33 | $301.01 |
| 2030 | $539.63 | $505.97 | 2030 | $328.92 | $308.40 |
| 2031 | $554.67 | $519.99 | 2031 | $331.46 | $310.74 |
| 2032 | $570.14 | $534.42 | 2032 | $334.03 | $313.09 |
| 2033 | $586.06 | $549.25 | 2033 | $336.62 | $315.47 |
| 2034 | $602.42 | $564.50 | 2034 | $339.23 | $317.88 |
| 2035 | $619.26 | $580.19 | 2035 | $341.87 | $320.31 |
| 2036 | $636.57 | $596.33 | 2036 | $344.54 | $322.76 |
| 2037 | $654.38 | $612.93 | 2037 | $347.24 | $325.24 |
| 2038 | $672.71 | $630.00 | 2038 | $349.96 | $327.74 |
| 2039 | $691.55 | $647.55 | 2039 | $352.71 | $330.27 |
| 2040 | $722.27 | $676.94 | 2040 | $361.15 | $338.49 |

## Figure 3-4

| Planned System Additions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Number of Projects? | | | | | If Downsize, then: | | | |
| Project Name | On-line Year | Capital Cost | Fixed O&M Cost | Defer/ Downsize? | Downsize Factor | Flow/ Volume? | Size Units | Size (Peak Season) |
| | | ($million) | ($/yr) | | | | | |
| GW # 1 | 2015 | $10 | | de | | | | |
| Annual Real Escalation Rates: | | 1% | 1% | | | | | |
| Financing Term (yrs): | 20 | | | | | | | |

## Figure 3-5

| Seasonal Multipliers for Planned Additions | | |
|---|---|---|
| | Peak | Off-Peak |
| | GW # 1 | GW # 1 |
| | 2015 | 2015 |
| Years | | |
| 2005 to 2009 | 0.00 | 0.00 |
| 2010 to 2014 | 1.00 | 0.00 |
| 2015 to 2019 | 1.00 | 0.00 |
| 2020 to 2024 | 1.00 | 0.00 |
| 2025 to 2029 | 1.00 | 0.00 |
| 2030 to 2034 | 1.00 | 0.00 |
| 2035 to 2039 | 1.00 | 0.00 |
| 2040 to 2044 | 1.00 | 0.00 |

## Figure 3-6

| Total Long-Run Avoided Costs by Season<br>Nominal Dollars | | | | |
|---|---|---|---|---|
| | Peak-Season | | Off-Peak Season | |
| | ($ million/mgd) | ($/mg) | ($ million/mgd) | ($/mg) |
| | | | | |
| 2005 | $0.0000 | $0 | $0.0000 | $0 |
| 2006 | $0.0000 | $0 | $0.0000 | $0 |
| 2007 | $0.0000 | $0 | $0.0000 | $0 |
| 2008 | $0.0000 | $0 | $0.0000 | $0 |
| 2009 | $0.0000 | $0 | $0.0000 | $0 |
| 2010 | $0.0000 | $0 | $0.0000 | $0 |
| 2011 | $0.0000 | $0 | $0.0000 | $0 |
| 2012 | $0.0000 | $0 | $0.0000 | $0 |
| 2013 | $0.0000 | $0 | $0.0000 | $0 |
| 2014 | $0.0000 | $0 | $0.0000 | $0 |
| 2015 | $0.0288 | $188 | $0.0000 | $0 |
| 2016 | $0.0288 | $188 | $0.0000 | $0 |
| 2017 | $0.0288 | $188 | $0.0000 | $0 |
| 2018 | $0.0288 | $188 | $0.0000 | $0 |
| 2019 | $0.0288 | $188 | $0.0000 | $0 |
| 2020 | $0.0288 | $188 | $0.0000 | $0 |
| 2021 | $0.0288 | $188 | $0.0000 | $0 |
| 2022 | $0.0288 | $188 | $0.0000 | $0 |
| 2023 | $0.0288 | $188 | $0.0000 | $0 |
| 2024 | $0.0288 | $188 | $0.0000 | $0 |
| 2025 | $0.0288 | $188 | $0.0000 | $0 |
| 2026 | $0.0288 | $188 | $0.0000 | $0 |
| 2027 | $0.0288 | $188 | $0.0000 | $0 |
| 2028 | $0.0288 | $188 | $0.0000 | $0 |
| 2029 | $0.0288 | $188 | $0.0000 | $0 |
| 2030 | $0.0288 | $188 | $0.0000 | $0 |
| 2031 | $0.0288 | $188 | $0.0000 | $0 |
| 2032 | $0.0288 | $188 | $0.0000 | $0 |
| 2033 | $0.0288 | $188 | $0.0000 | $0 |
| 2034 | $0.0288 | $188 | $0.0000 | $0 |
| 2035 | $0.0000 | $0 | $0.0000 | $0 |
| 2036 | $0.0000 | $0 | $0.0000 | $0 |
| 2037 | $0.0000 | $0 | $0.0000 | $0 |
| 2038 | $0.0000 | $0 | $0.0000 | $0 |
| 2039 | $0.0000 | $0 | $0.0000 | $0 |
| 2040 | $0.0000 | $0 | $0.0000 | $0 |

## Figure 3-7

| Total Direct Utility Avoided Costs: Nominal Dollars ($/mg) | | | | | | |
|---|---|---|---|---|---|---|
| Year | Peak Season | | | Off-Peak Season | | |
| | Short-Run | Long-Run | Total | Short-Run | Long-Run | Total |
| 2005 | $245 | $0 | **$245** | $245 | $0 | **$245** |
| 2006 | $252 | $0 | **$252** | $252 | $0 | **$252** |
| 2007 | $258 | $0 | **$258** | $258 | $0 | **$258** |
| 2008 | $265 | $0 | **$265** | $265 | $0 | **$265** |
| 2009 | $273 | $0 | **$273** | $273 | $0 | **$273** |
| 2010 | $280 | $0 | **$280** | $280 | $0 | **$280** |
| 2011 | $288 | $0 | **$288** | $288 | $0 | **$288** |
| 2012 | $296 | $0 | **$296** | $296 | $0 | **$296** |
| 2013 | $304 | $0 | **$304** | $304 | $0 | **$304** |
| 2014 | $312 | $0 | **$312** | $312 | $0 | **$312** |
| 2015 | $353 | $188 | **$541** | $331 | $0 | **$331** |
| 2016 | $362 | $188 | **$551** | $340 | $0 | **$340** |
| 2017 | $372 | $188 | **$561** | $349 | $0 | **$349** |
| 2018 | $383 | $188 | **$571** | $359 | $0 | **$359** |
| 2019 | $393 | $188 | **$582** | $369 | $0 | **$369** |
| 2020 | $404 | $188 | **$592** | $379 | $0 | **$379** |
| 2021 | $415 | $188 | **$604** | $389 | $0 | **$389** |
| 2022 | $427 | $188 | **$615** | $400 | $0 | **$400** |
| 2023 | $439 | $188 | **$627** | $411 | $0 | **$411** |
| 2024 | $451 | $188 | **$639** | $423 | $0 | **$423** |
| 2025 | $463 | $188 | **$652** | $434 | $0 | **$434** |
| 2026 | $476 | $188 | **$664** | $446 | $0 | **$446** |
| 2027 | $489 | $188 | **$678** | $458 | $0 | **$458** |
| 2028 | $503 | $188 | **$691** | $471 | $0 | **$471** |
| 2029 | $517 | $188 | **$705** | $484 | $0 | **$484** |
| 2030 | $540 | $188 | **$728** | $506 | $0 | **$506** |
| 2031 | $555 | $188 | **$743** | $520 | $0 | **$520** |
| 2032 | $570 | $188 | **$759** | $534 | $0 | **$534** |
| 2033 | $586 | $188 | **$774** | $549 | $0 | **$549** |
| 2034 | $602 | $188 | **$791** | $565 | $0 | **$565** |
| 2035 | $619 | $0 | **$619** | $580 | $0 | **$580** |
| 2036 | $637 | $0 | **$637** | $596 | $0 | **$596** |
| 2037 | $654 | $0 | **$654** | $613 | $0 | **$613** |
| 2038 | $673 | $0 | **$673** | $630 | $0 | **$630** |
| 2039 | $692 | $0 | **$692** | $648 | $0 | **$648** |
| 2040 | $722 | $0 | **$722** | $677 | $0 | **$677** |

## Figure 4-1

**Variable Operating Costs**

Number of Components?

| Component Type | Component Name | Existing or Planned? | On-Line Year (for Planned) | Loss Rate | Ref. Year Power Costs | Ref. Year Chemical Costs | Ref. Year Purchase Costs | Ref. Year Other Costs | Ref. Year Revenues |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | ($/mg) | ($/mg) | ($/mg) | ($/mg) | |
| Su | Diversion A | e | | | $20 | | | | |
| T | WTP A | e | | | $150 | $75 | | | |
| Su | GW # 1 | p | 2015 | | $100 | | | | |
| CP | Path Group 25 | e | | | $25 | | | | |
| | | | Annual Real Escalation Rates: | | 1.00% | 0.00% | 2.00% | 0.00% | 0.00% |

## Figure 4-2a

**On Margin Probabilities:**
**Optional Sheet for Condition 1**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Condition:** | Wet | | | | | |
| | **Weight:** | 30% | **Diversion A** | **WTP A** | **GW #1** | **Path Group 25** |
| | | ***On-line dates:*** | | | *2015* | |
| **Year** | **Season** | ***Type:*** | *Su* | *T* | *Su* | *CP* |
| 2005 | Peak | | 100% | 100% | 0% | 20% |
| to 2009 | Off-Peak | | 100% | 100% | 0% | 10% |
| 2010 | Peak | | 100% | 100% | 0% | 20% |
| to 2014 | Off-Peak | | 100% | 100% | 0% | 10% |
| 2015 | Peak | | 80% | 100% | 10% | 30% |
| to 2019 | Off-Peak | | 90% | 100% | 10% | 10% |
| 2020 | Peak | | 85% | 100% | 15% | 30% |
| to 2024 | Off-Peak | | 90% | 100% | 10% | 10% |
| 2025 | Peak | | 80% | 100% | 20% | 40% |
| to 2029 | Off-Peak | | 85% | 100% | 15% | 10% |
| 2030 | Peak | | 75% | 100% | 25% | 50% |
| to 2034 | Off-Peak | | 80% | 100% | 20% | 10% |
| 2035 | Peak | | 75% | 100% | 25% | 50% |
| to 2039 | Off-Peak | | 80% | 100% | 20% | 10% |
| 2040 | Peak | | 75% | 100% | 25% | 50% |
| to 2044 | Off-Peak | | 80% | 100% | 20% | 10% |

# Figure 4-2b

**On Margin Probabilities:**
**Optional Sheet for Condition 2**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Condition:** | Average | | | | | |
| | **Weight:** | 50% | **Diversion A** | **WTP A** | **GW #1** | **Path Group 25** |
| | | ***On-line dates:*** | | | *2015* | |
| **Year** | **Season** | ***Type:*** | *Su* | *T* | *Su* | *CP* |
| 2005 | Peak | | 100% | 100% | 0% | 20% |
| to 2009 | Off-Peak | | 100% | 100% | 0% | 10% |
| 2010 | Peak | | 100% | 100% | 0% | 20% |
| to 2014 | Off-Peak | | 100% | 100% | 0% | 10% |
| 2015 | Peak | | 70% | 100% | 30% | 30% |
| to 2019 | Off-Peak | | 90% | 100% | 10% | 10% |
| 2020 | Peak | | 65% | 100% | 35% | 30% |
| to 2024 | Off-Peak | | 85% | 100% | 15% | 10% |
| 2025 | Peak | | 60% | 100% | 40% | 40% |
| to 2029 | Off-Peak | | 80% | 100% | 20% | 10% |
| 2030 | Peak | | 55% | 100% | 45% | 50% |
| to 2034 | Off-Peak | | 75% | 100% | 25% | 10% |
| 2035 | Peak | | 55% | 100% | 45% | 50% |
| to 2039 | Off-Peak | | 75% | 100% | 25% | 10% |
| 2040 | Peak | | 55% | 100% | 45% | 50% |
| to 2044 | Off-Peak | | 75% | 100% | 25% | 10% |

## Figure 4-2c

**On Margin Probabilities:**
**Optional Sheet for Condition 3**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Condition:** | Dry | | | | | |
| | **Weight:** 20% | | **Diversion A** | **WTP A** | **GW #1** | **Path Group 25** |
| | | ***On-line dates:*** | | | *2015* | |
| **Year** | **Season** | ***Type:*** | *Su* | *T* | *Su* | *CP* |
| 2005 | Peak | | 100% | 100% | 0% | 20% |
| to 2009 | Off-Peak | | 100% | 100% | 0% | 10% |
| 2010 | Peak | | 100% | 100% | 0% | 20% |
| to 2014 | Off-Peak | | 100% | 100% | 0% | 10% |
| 2015 | Peak | | 50% | 100% | 50% | 30% |
| to 2019 | Off-Peak | | 80% | 100% | 20% | 10% |
| 2020 | Peak | | 45% | 100% | 55% | 30% |
| to 2024 | Off-Peak | | 75% | 100% | 25% | 10% |
| 2025 | Peak | | 40% | 100% | 60% | 40% |
| to 2029 | Off-Peak | | 70% | 100% | 30% | 10% |
| 2030 | Peak | | 35% | 100% | 65% | 50% |
| to 2034 | Off-Peak | | 65% | 100% | 35% | 10% |
| 2035 | Peak | | 35% | 100% | 65% | 50% |
| to 2039 | Off-Peak | | 65% | 100% | 35% | 10% |
| 2040 | Peak | | 35% | 100% | 65% | 50% |
| to 2044 | Off-Peak | | 65% | 100% | 35% | 10% |

## Figure 4-2d

**System Components:**
**On-Margin Probabilities**

| | | | Diversion A | WTP A | GW #1 | Path Group 25 |
|---|---|---|---|---|---|---|
| | | *On-line dates:* | | | *2015* | |
| | | | | | | |
| **Year** | **Season** | ***Type:*** | *Su* | *T* | *Su* | *CP* |
| 2005 | Peak | | 100% | 100% | 0% | 20% |
| to 2009 | Off-Peak | | 100% | 100% | 0% | 10% |
| 2010 | Peak | | 100% | 100% | 0% | 20% |
| to 2014 | Off-Peak | | 100% | 100% | 0% | 10% |
| 2015 | Peak | | 69% | 100% | 28% | 30% |
| to 2019 | Off-Peak | | 88% | 100% | 12% | 10% |
| 2020 | Peak | | 67% | 100% | 33% | 30% |
| to 2024 | Off-Peak | | 85% | 100% | 16% | 10% |
| 2025 | Peak | | 62% | 100% | 38% | 40% |
| to 2029 | Off-Peak | | 80% | 100% | 21% | 10% |
| 2030 | Peak | | 57% | 100% | 43% | 50% |
| to 2034 | Off-Peak | | 75% | 100% | 26% | 10% |
| 2035 | Peak | | 57% | 100% | 43% | 50% |
| to 2039 | Off-Peak | | 75% | 100% | 26% | 10% |
| 2040 | Peak | | 57% | 100% | 43% | 50% |
| to 2044 | Off-Peak | | 75% | 100% | 26% | 10% |

## Figure 4-3

### Short-Run Avoided Costs
### ($/mg)

**Annual Short-Run Avoided Costs by Season — Nominal Dollars**

| Year | Peak-Season | Off-Peak Season |
|---|---|---|
| 2005 | $250.00 | $247.50 |
| 2006 | $256.79 | $254.21 |
| 2007 | $263.76 | $261.11 |
| 2008 | $270.93 | $268.20 |
| 2009 | $278.30 | $275.48 |
| 2010 | $285.88 | $282.98 |
| 2011 | $293.66 | $290.68 |
| 2012 | $301.67 | $298.59 |
| 2013 | $309.90 | $306.73 |
| 2014 | $318.37 | $315.10 |
| 2015 | $359.79 | $336.63 |
| 2016 | $369.72 | $345.86 |
| 2017 | $379.94 | $355.35 |
| 2018 | $390.44 | $365.12 |
| 2019 | $401.24 | $375.15 |
| 2020 | $419.54 | $389.85 |
| 2021 | $431.18 | $400.59 |
| 2022 | $443.15 | $411.64 |
| 2023 | $455.46 | $423.00 |
| 2024 | $468.12 | $434.68 |
| 2025 | $492.93 | $453.95 |
| 2026 | $506.68 | $466.52 |
| 2027 | $520.82 | $479.45 |
| 2028 | $535.37 | $492.75 |
| 2029 | $550.33 | $506.42 |
| 2030 | $579.40 | $528.90 |
| 2031 | $595.64 | $543.62 |
| 2032 | $612.35 | $558.76 |
| 2033 | $629.53 | $574.32 |
| 2034 | $647.21 | $590.34 |
| 2035 | $665.40 | $606.81 |
| 2036 | $684.11 | $623.75 |
| 2037 | $703.36 | $641.17 |
| 2038 | $723.16 | $659.09 |
| 2039 | $743.53 | $677.53 |
| 2040 | $764.48 | $696.49 |

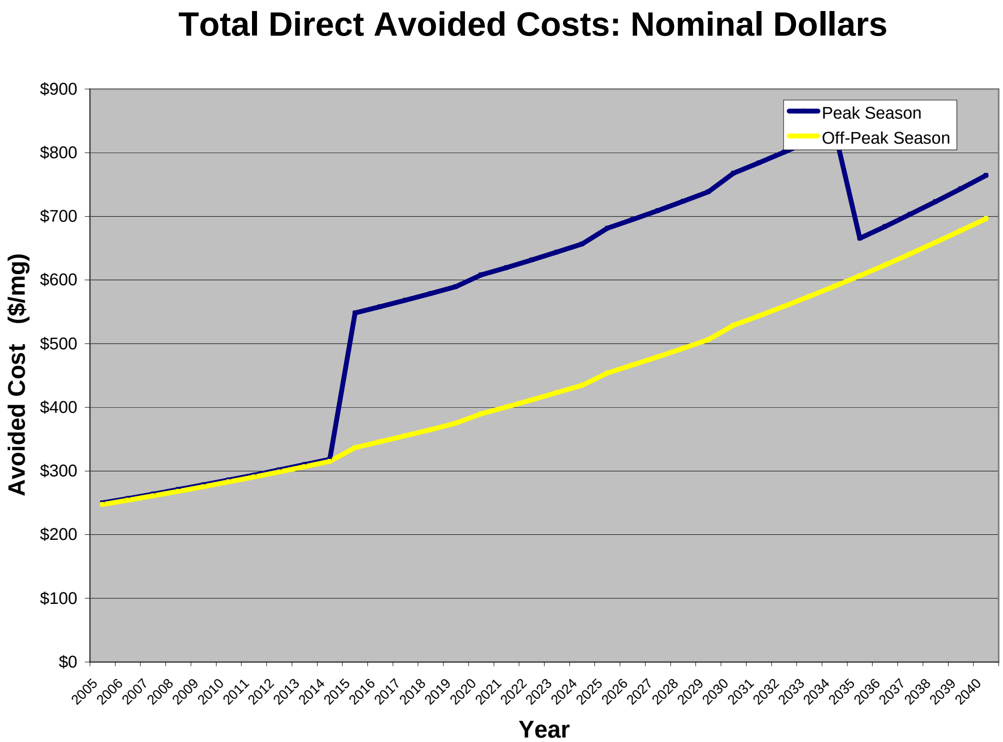
**Annual Short-Run Avoided Costs by Season — 2005 Dollars**

| Year | Peak-Season | Off-Peak Season |
|---|---|---|
| 2005 | $250.00 | $247.50 |
| 2006 | $251.75 | $249.23 |
| 2007 | $253.52 | $250.97 |
| 2008 | $255.30 | $252.73 |
| 2009 | $257.11 | $254.50 |
| 2010 | $258.93 | $256.30 |
| 2011 | $260.77 | $258.11 |
| 2012 | $262.62 | $259.94 |
| 2013 | $264.50 | $261.79 |
| 2014 | $266.39 | $263.66 |
| 2015 | $295.15 | $276.15 |
| 2016 | $297.35 | $278.16 |
| 2017 | $299.58 | $280.19 |
| 2018 | $301.82 | $282.25 |
| 2019 | $304.09 | $284.32 |
| 2020 | $311.72 | $289.66 |
| 2021 | $314.09 | $291.81 |
| 2022 | $316.48 | $293.98 |
| 2023 | $318.89 | $296.17 |
| 2024 | $321.33 | $298.38 |
| 2025 | $331.73 | $305.49 |
| 2026 | $334.30 | $307.80 |
| 2027 | $336.89 | $310.13 |
| 2028 | $339.51 | $312.48 |
| 2029 | $342.15 | $314.85 |
| 2030 | $353.16 | $322.38 |
| 2031 | $355.94 | $324.85 |
| 2032 | $358.75 | $327.35 |
| 2033 | $361.59 | $329.88 |
| 2034 | $364.45 | $332.43 |
| 2035 | $367.35 | $335.00 |
| 2036 | $370.27 | $337.60 |
| 2037 | $373.22 | $340.23 |
| 2038 | $376.21 | $342.88 |
| 2039 | $379.22 | $345.56 |
| 2040 | $382.26 | $348.26 |

**Figure 4-4**

| Total Direct Utility Avoided Costs: Nominal Dollars ($/mg) | | | | | | |
|---|---|---|---|---|---|---|
| Year | Peak Season | | | Off-Peak Season | | |
| | Short-Run | Long-Run | Total | Short-Run | Long-Run | Total |
| 2005 | $250 | $0 | **$250** | $248 | $0 | **$248** |
| 2006 | $257 | $0 | **$257** | $254 | $0 | **$254** |
| 2007 | $264 | $0 | **$264** | $261 | $0 | **$261** |
| 2008 | $271 | $0 | **$271** | $268 | $0 | **$268** |
| 2009 | $278 | $0 | **$278** | $275 | $0 | **$275** |
| 2010 | $286 | $0 | **$286** | $283 | $0 | **$283** |
| 2011 | $294 | $0 | **$294** | $291 | $0 | **$291** |
| 2012 | $302 | $0 | **$302** | $299 | $0 | **$299** |
| 2013 | $310 | $0 | **$310** | $307 | $0 | **$307** |
| 2014 | $318 | $0 | **$318** | $315 | $0 | **$315** |
| 2015 | $360 | $188 | **$548** | $337 | $0 | **$337** |
| 2016 | $370 | $188 | **$558** | $346 | $0 | **$346** |
| 2017 | $380 | $188 | **$568** | $355 | $0 | **$355** |
| 2018 | $390 | $188 | **$579** | $365 | $0 | **$365** |
| 2019 | $401 | $188 | **$590** | $375 | $0 | **$375** |
| 2020 | $420 | $188 | **$608** | $390 | $0 | **$390** |
| 2021 | $431 | $188 | **$620** | $401 | $0 | **$401** |
| 2022 | $443 | $188 | **$632** | $412 | $0 | **$412** |
| 2023 | $455 | $188 | **$644** | $423 | $0 | **$423** |
| 2024 | $468 | $188 | **$657** | $435 | $0 | **$435** |
| 2025 | $493 | $188 | **$681** | $454 | $0 | **$454** |
| 2026 | $507 | $188 | **$695** | $467 | $0 | **$467** |
| 2027 | $521 | $188 | **$709** | $479 | $0 | **$479** |
| 2028 | $535 | $188 | **$724** | $493 | $0 | **$493** |
| 2029 | $550 | $188 | **$739** | $506 | $0 | **$506** |
| 2030 | $579 | $188 | **$768** | $529 | $0 | **$529** |
| 2031 | $596 | $188 | **$784** | $544 | $0 | **$544** |
| 2032 | $612 | $188 | **$801** | $559 | $0 | **$559** |
| 2033 | $630 | $188 | **$818** | $574 | $0 | **$574** |
| 2034 | $647 | $188 | **$836** | $590 | $0 | **$590** |
| 2035 | $665 | $0 | **$665** | $607 | $0 | **$607** |
| 2036 | $684 | $0 | **$684** | $624 | $0 | **$624** |
| 2037 | $703 | $0 | **$703** | $641 | $0 | **$641** |
| 2038 | $723 | $0 | **$723** | $659 | $0 | **$659** |
| 2039 | $744 | $0 | **$744** | $678 | $0 | **$678** |
| 2040 | $764 | $0 | **$764** | $696 | $0 | **$696** |

## Figure 4-5



Total Direct Avoided Costs: Nominal Dollars
$900
$800
$700
$600
$500
$400
$300
$200
$100
$0
Avoided Cost ($/mg)
Peak Season
Off-Peak Season
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Year

## Figure 5-1

| Component Type | Component Name | Existing or Planned? | On-Line Year (for Planned) | Loss Rate | Ref. Year Power Costs ($/mg) | Ref. Year Chemical Costs ($/mg) | Ref. Year Purchase Costs ($/mg) | Ref. Year Other Costs ($/mg) | Ref. Year Revenues ($/mg) |
|---|---|---|---|---|---|---|---|---|---|
| Su | Diversion A | e | | 5% | $20 | | | | $10 |
| T | WTP A | e | | | $150 | $75 | | | |
| Su | GW #1 | p | 2015 | 20% | $100 | | | | |
| CP | Path Group 25 | e | | | $25 | | | | |
| CP | Path Group 50 | p | 2010 | | $50 | | | | |
| | | | Annual Real Escalation Rates: | | 1.00% | 0.00% | 2.00% | 0.00% | 0.00% |

Number of Components?

Variable Operating Costs

## Figure 5-2

**System Components:**
**On-Margin Probabilities**

| Year | Season | | Diversion A | WTP A | GW #1 | Path Group 25 | Path Group 50 |
|---|---|---|---|---|---|---|---|
| | | *On-line dates:* | | | *2015* | | *2010* |
| | | *Type:* | *Su* | *T* | *Su* | *CP* | *CP* |
| 2005 to 2009 | Peak | | 100% | 100% | 0% | 20% | 0% |
| | Off-Peak | | 100% | 100% | 0% | 10% | 0% |
| 2010 to 2014 | Peak | | 70% | 100% | 0% | 20% | 30% |
| | Off-Peak | | 80% | 100% | 0% | 10% | 20% |
| 2015 to 2019 | Peak | | 50% | 100% | 30% | 30% | 30% |
| | Off-Peak | | 80% | 100% | 10% | 10% | 20% |
| 2020 to 2024 | Peak | | 40% | 100% | 30% | 30% | 25% |
| | Off-Peak | | 80% | 100% | 10% | 10% | 20% |
| 2025 to 2029 | Peak | | 45% | 100% | 40% | 40% | 25% |
| | Off-Peak | | 85% | 100% | 10% | 10% | 15% |
| 2030 to 2034 | Peak | | 55% | 100% | 40% | 50% | 20% |
| | Off-Peak | | 90% | 100% | 10% | 10% | 10% |
| 2035 to 2039 | Peak | | 55% | 100% | 40% | 50% | 20% |
| | Off-Peak | | 90% | 100% | 10% | 10% | 10% |
| 2040 to 2044 | Peak | | 55% | 100% | 40% | 50% | 20% |
| | Off-Peak | | 90% | 100% | 10% | 10% | 10% |

# Figure 5-3

## Short-Run Avoided Costs
## ($/mg)

| Annual Short-Run Avoided Costs by Season — Nominal Dollars | | | Annual Short-Run Avoided Costs by Season — 2005 Dollars | | |
|---|---|---|---|---|---|
| Year | Peak-Season | Off-Peak Season | Year | Peak-Season | Off-Peak Season |
| 2005 | $240.53 | $238.03 | 2005 | $240.53 | $238.03 |
| 2006 | $247.13 | $244.56 | 2006 | $242.29 | $239.76 |
| 2007 | $253.93 | $251.27 | 2007 | $244.06 | $241.51 |
| 2008 | $260.91 | $258.18 | 2008 | $245.86 | $243.29 |
| 2009 | $268.09 | $265.28 | 2009 | $247.67 | $245.07 |
| 2010 | $289.04 | $281.62 | 2010 | $261.79 | $255.07 |
| 2011 | $297.01 | $289.37 | 2011 | $263.73 | $256.95 |
| 2012 | $305.20 | $297.35 | 2012 | $265.69 | $258.86 |
| 2013 | $313.62 | $305.55 | 2013 | $267.68 | $260.78 |
| 2014 | $322.29 | $313.98 | 2014 | $269.68 | $262.72 |
| 2015 | $381.95 | $339.48 | 2015 | $313.34 | $278.49 |
| 2016 | $392.62 | $348.90 | 2016 | $315.77 | $280.61 |
| 2017 | $403.59 | $358.60 | 2017 | $318.23 | $282.75 |
| 2018 | $414.88 | $368.57 | 2018 | $320.72 | $284.91 |
| 2019 | $426.49 | $378.82 | 2019 | $323.23 | $287.10 |
| 2020 | $432.65 | $389.36 | 2020 | $321.47 | $289.30 |
| 2021 | $444.75 | $400.21 | 2021 | $323.97 | $291.53 |
| 2022 | $457.19 | $411.36 | 2022 | $326.51 | $293.78 |
| 2023 | $469.98 | $422.83 | 2023 | $329.06 | $296.05 |
| 2024 | $483.15 | $434.63 | 2024 | $331.65 | $298.35 |
| 2025 | $525.01 | $443.36 | 2025 | $353.32 | $298.37 |
| 2026 | $539.80 | $455.75 | 2026 | $356.15 | $300.69 |
| 2027 | $555.01 | $468.49 | 2027 | $359.00 | $303.04 |
| 2028 | $570.67 | $481.60 | 2028 | $361.89 | $305.41 |
| 2029 | $586.77 | $495.08 | 2029 | $364.81 | $307.80 |
| 2030 | $606.04 | $505.04 | 2030 | $369.40 | $307.84 |
| 2031 | $623.19 | $519.20 | 2031 | $372.40 | $310.26 |
| 2032 | $640.82 | $533.76 | 2032 | $375.43 | $312.71 |
| 2033 | $658.97 | $548.74 | 2033 | $378.50 | $315.18 |
| 2034 | $677.64 | $564.15 | 2034 | $381.59 | $317.68 |
| 2035 | $696.86 | $580.00 | 2035 | $384.71 | $320.20 |
| 2036 | $716.62 | $596.30 | 2036 | $387.87 | $322.75 |
| 2037 | $736.96 | $613.07 | 2037 | $391.06 | $325.32 |
| 2038 | $757.89 | $630.33 | 2038 | $394.27 | $327.92 |
| 2039 | $779.42 | $648.08 | 2039 | $397.52 | $330.54 |
| 2040 | $801.57 | $666.34 | 2040 | $400.81 | $333.19 |

## Figure 5-4

**Planned System Additions**

**Number of Projects?**

| Project Name | On-line Year | Capital Cost ($million) | Fixed O&M Cost ($/yr) | Defer/ Downsize? | If Downsize, then: Downsize Factor | Flow/ Volume? | Size Units | Size (Peak Season) |
|---|---|---|---|---|---|---|---|---|
| GW # 1 | 2015 | $10 | | de | | | | |
| Reservoir North | 2010 | $100 | $100,000 | de | | | | |
| Pipeline North | 2010 | $20 | | de | | | | |

| | | |
|---|---|---|
| **Annual Real Escalation Rates:** | 1% | 1% |
| **Financing Term (yrs):** | 20 | |

## Figure 5-5

**Seasonal Multipliers for Planned Additions**

| | Peak | | | Off-Peak | | |
|---|---|---|---|---|---|---|
| | GW # 1 | Reservoir North | Pipeline North | GW # 1 | Reservoir North | Pipeline North |
| | *2015* | *2010* | *2010* | *2015* | *2010* | *2010* |
| Years | | | | | | |
| **2005 to 2009** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **2010 to 2014** | 0.00 | 1.00 | 0.70 | 0.00 | 0.00 | 0.00 |
| **2015 to 2019** | 1.00 | 1.00 | 0.70 | 0.00 | 0.00 | 0.00 |
| **2020 to 2024** | 1.00 | 1.00 | 0.70 | 0.00 | 0.60 | 0.00 |
| **2025 to 2029** | 1.00 | 1.00 | 0.70 | 0.00 | 0.60 | 0.00 |
| **2030 to 2034** | 1.00 | 1.00 | 0.70 | 0.00 | 0.70 | 0.00 |
| **2035 to 2039** | 1.00 | 1.00 | 0.70 | 0.00 | 0.70 | 0.00 |
| **2040 to 2044** | 1.00 | 1.00 | 0.70 | 0.00 | 0.70 | 0.00 |

## Figure 5-6

| Total Long-Run Avoided Costs by Season<br>Nominal Dollars | | | | |
|---|---|---|---|---|
| | Peak-Season | | Off-Peak Season | |
| | ($ million/mgd) | ($/mg) | ($ million/mgd) | ($/mg) |
| | | | | |
| 2005 | $0.0000 | $0 | $0.0000 | $0 |
| 2006 | $0.0000 | $0 | $0.0000 | $0 |
| 2007 | $0.0000 | $0 | $0.0000 | $0 |
| 2008 | $0.0000 | $0 | $0.0000 | $0 |
| 2009 | $0.0000 | $0 | $0.0000 | $0 |
| 2010 | $0.1527 | $998 | $0.0000 | $0 |
| 2011 | $0.1527 | $998 | $0.0000 | $0 |
| 2012 | $0.1528 | $999 | $0.0000 | $0 |
| 2013 | $0.1528 | $999 | $0.0000 | $0 |
| 2014 | $0.1529 | $999 | $0.0000 | $0 |
| 2015 | $0.1818 | $1,188 | $0.0000 | $0 |
| 2016 | $0.1818 | $1,188 | $0.0000 | $0 |
| 2017 | $0.1819 | $1,189 | $0.0000 | $0 |
| 2018 | $0.1819 | $1,189 | $0.0000 | $0 |
| 2019 | $0.1820 | $1,189 | $0.0000 | $0 |
| 2020 | $0.1820 | $1,190 | $0.0808 | $381 |
| 2021 | $0.1821 | $1,190 | $0.0808 | $381 |
| 2022 | $0.1822 | $1,191 | $0.0809 | $381 |
| 2023 | $0.1822 | $1,191 | $0.0809 | $382 |
| 2024 | $0.1823 | $1,192 | $0.0809 | $382 |
| 2025 | $0.1824 | $1,192 | $0.0810 | $382 |
| 2026 | $0.1824 | $1,192 | $0.0810 | $382 |
| 2027 | $0.1825 | $1,193 | $0.0811 | $382 |
| 2028 | $0.1826 | $1,193 | $0.0811 | $383 |
| 2029 | $0.1827 | $1,194 | $0.0812 | $383 |
| 2030 | $0.0316 | $206 | $0.0019 | $9 |
| 2031 | $0.0317 | $207 | $0.0020 | $9 |
| 2032 | $0.0318 | $208 | $0.0020 | $10 |
| 2033 | $0.0318 | $208 | $0.0021 | $10 |
| 2034 | $0.0319 | $209 | $0.0022 | $10 |
| 2035 | $0.0032 | $21 | $0.0022 | $11 |
| 2036 | $0.0033 | $22 | $0.0023 | $11 |
| 2037 | $0.0034 | $22 | $0.0024 | $11 |
| 2038 | $0.0035 | $23 | $0.0024 | $12 |
| 2039 | $0.0036 | $24 | $0.0025 | $12 |
| 2040 | $0.0037 | $24 | $0.0026 | $12 |

**Figure 5-7**

| Total Direct Utility Avoided Costs: Nominal Dollars ($/mg) | | | | | | |
|---|---|---|---|---|---|---|
| Year | Peak Season | | | Off-Peak Season | | |
| | Short-Run | Long-Run | Total | Short-Run | Long-Run | Total |
| 2005 | $241 | $0 | **$241** | $238 | $0 | **$238** |
| 2006 | $247 | $0 | **$247** | $245 | $0 | **$245** |
| 2007 | $254 | $0 | **$254** | $251 | $0 | **$251** |
| 2008 | $261 | $0 | **$261** | $258 | $0 | **$258** |
| 2009 | $268 | $0 | **$268** | $265 | $0 | **$265** |
| 2010 | $289 | $998 | **$1,287** | $282 | $0 | **$282** |
| 2011 | $297 | $998 | **$1,295** | $289 | $0 | **$289** |
| 2012 | $305 | $999 | **$1,304** | $297 | $0 | **$297** |
| 2013 | $314 | $999 | **$1,313** | $306 | $0 | **$306** |
| 2014 | $322 | $999 | **$1,322** | $314 | $0 | **$314** |
| 2015 | $382 | $1,188 | **$1,570** | $339 | $0 | **$339** |
| 2016 | $393 | $1,188 | **$1,581** | $349 | $0 | **$349** |
| 2017 | $404 | $1,189 | **$1,592** | $359 | $0 | **$359** |
| 2018 | $415 | $1,189 | **$1,604** | $369 | $0 | **$369** |
| 2019 | $426 | $1,189 | **$1,616** | $379 | $0 | **$379** |
| 2020 | $433 | $1,190 | **$1,622** | $389 | $381 | **$770** |
| 2021 | $445 | $1,190 | **$1,635** | $400 | $381 | **$781** |
| 2022 | $457 | $1,191 | **$1,648** | $411 | $381 | **$793** |
| 2023 | $470 | $1,191 | **$1,661** | $423 | $382 | **$804** |
| 2024 | $483 | $1,192 | **$1,675** | $435 | $382 | **$816** |
| 2025 | $525 | $1,192 | **$1,717** | $443 | $382 | **$825** |
| 2026 | $540 | $1,192 | **$1,732** | $456 | $382 | **$838** |
| 2027 | $555 | $1,193 | **$1,748** | $468 | $382 | **$851** |
| 2028 | $571 | $1,193 | **$1,764** | $482 | $383 | **$864** |
| 2029 | $587 | $1,194 | **$1,781** | $495 | $383 | **$878** |
| 2030 | $606 | $206 | **$812** | $505 | $9 | **$514** |
| 2031 | $623 | $207 | **$830** | $519 | $9 | **$529** |
| 2032 | $641 | $208 | **$848** | $534 | $10 | **$543** |
| 2033 | $659 | $208 | **$867** | $549 | $10 | **$559** |
| 2034 | $678 | $209 | **$886** | $564 | $10 | **$574** |
| 2035 | $697 | $21 | **$718** | $580 | $11 | **$591** |
| 2036 | $717 | $22 | **$738** | $596 | $11 | **$607** |
| 2037 | $737 | $22 | **$759** | $613 | $11 | **$624** |
| 2038 | $758 | $23 | **$781** | $630 | $12 | **$642** |
| 2039 | $779 | $24 | **$803** | $648 | $12 | **$660** |
| 2040 | $802 | $24 | **$826** | $666 | $12 | **$679** |

## Figure 6-1

| Planned System Additions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Number of Projects? | | | | If Downsize, then: | | | | |
| Project Name | On-line Year | Capital Cost | Fixed O&M Cost | Defer/ Downsize? | Downsize Factor | Flow/ Volume? | Size Units | Size (Peak Season) |
| | | ($million) | ($/yr) | | | | | |
| GW # 1 | 2015 | $10 | | do | 0.8 | f | mgd | 10 |
| Reservoir North | 2010 | $100 | $100,000 | de | | | | |
| Pipeline North | 2010 | $20 | | | | | | |
| Annual Real Escalation Rates: | | 1% | 1% | | | | | |

## Figure 6-2

| Total Long-Run Avoided Costs by Season<br>Nominal Dollars | | | | |
|---|---|---|---|---|
| | Peak-Season | | Off-Peak Season | |
| | ($ million/mgd) | ($/mg) | ($ million/mgd) | ($/mg) |
| | | | | |
| 2005 | $0.0000 | $0 | $0.0000 | $0 |
| 2006 | $0.0000 | $0 | $0.0000 | $0 |
| 2007 | $0.0000 | $0 | $0.0000 | $0 |
| 2008 | $0.0000 | $0 | $0.0000 | $0 |
| 2009 | $0.0000 | $0 | $0.0000 | $0 |
| 2010 | $0.1527 | $998 | $0.0000 | $0 |
| 2011 | $0.1527 | $998 | $0.0000 | $0 |
| 2012 | $0.1528 | $999 | $0.0000 | $0 |
| 2013 | $0.1528 | $999 | $0.0000 | $0 |
| 2014 | $0.1529 | $999 | $0.0000 | $0 |
| 2015 | $0.2469 | $1,613 | $0.0000 | $0 |
| 2016 | $0.2469 | $1,614 | $0.0000 | $0 |
| 2017 | $0.2470 | $1,614 | $0.0000 | $0 |
| 2018 | $0.2470 | $1,614 | $0.0000 | $0 |
| 2019 | $0.2471 | $1,615 | $0.0000 | $0 |
| 2020 | $0.2471 | $1,615 | $0.0808 | $381 |
| 2021 | $0.2472 | $1,616 | $0.0808 | $381 |
| 2022 | $0.2473 | $1,616 | $0.0809 | $381 |
| 2023 | $0.2473 | $1,617 | $0.0809 | $382 |
| 2024 | $0.2474 | $1,617 | $0.0809 | $382 |
| 2025 | $0.2475 | $1,617 | $0.0810 | $382 |
| 2026 | $0.2475 | $1,618 | $0.0810 | $382 |
| 2027 | $0.2476 | $1,618 | $0.0811 | $382 |
| 2028 | $0.2477 | $1,619 | $0.0811 | $383 |
| 2029 | $0.2478 | $1,619 | $0.0812 | $383 |
| 2030 | $0.0967 | $632 | $0.0019 | $9 |
| 2031 | $0.0968 | $632 | $0.0020 | $9 |
| 2032 | $0.0968 | $633 | $0.0020 | $10 |
| 2033 | $0.0969 | $634 | $0.0021 | $10 |
| 2034 | $0.0970 | $634 | $0.0022 | $10 |
| 2035 | $0.0032 | $21 | $0.0022 | $11 |
| 2036 | $0.0033 | $22 | $0.0023 | $11 |
| 2037 | $0.0034 | $22 | $0.0024 | $11 |
| 2038 | $0.0035 | $23 | $0.0024 | $12 |
| 2039 | $0.0036 | $24 | $0.0025 | $12 |
| 2040 | $0.0037 | $24 | $0.0026 | $12 |

## Figure 6-3

| Total Direct Utility Avoided Costs: Nominal Dollars ($/mg) | | | | | | |
|---|---|---|---|---|---|---|
| Year | Peak Season | | | Off-Peak Season | | |
| | Short-Run | Long-Run | Total | Short-Run | Long-Run | Total |
| 2005 | $241 | $0 | **$241** | $238 | $0 | **$238** |
| 2006 | $247 | $0 | **$247** | $245 | $0 | **$245** |
| 2007 | $254 | $0 | **$254** | $251 | $0 | **$251** |
| 2008 | $261 | $0 | **$261** | $258 | $0 | **$258** |
| 2009 | $268 | $0 | **$268** | $265 | $0 | **$265** |
| 2010 | $289 | $998 | **$1,287** | $282 | $0 | **$282** |
| 2011 | $297 | $998 | **$1,295** | $289 | $0 | **$289** |
| 2012 | $305 | $999 | **$1,304** | $297 | $0 | **$297** |
| 2013 | $314 | $999 | **$1,313** | $306 | $0 | **$306** |
| 2014 | $322 | $999 | **$1,322** | $314 | $0 | **$314** |
| 2015 | $382 | $1,613 | **$1,995** | $339 | $0 | **$339** |
| 2016 | $393 | $1,614 | **$2,006** | $349 | $0 | **$349** |
| 2017 | $404 | $1,614 | **$2,018** | $359 | $0 | **$359** |
| 2018 | $415 | $1,614 | **$2,029** | $369 | $0 | **$369** |
| 2019 | $426 | $1,615 | **$2,041** | $379 | $0 | **$379** |
| 2020 | $433 | $1,615 | **$2,048** | $389 | $381 | **$770** |
| 2021 | $445 | $1,616 | **$2,060** | $400 | $381 | **$781** |
| 2022 | $457 | $1,616 | **$2,073** | $411 | $381 | **$793** |
| 2023 | $470 | $1,617 | **$2,086** | $423 | $382 | **$804** |
| 2024 | $483 | $1,617 | **$2,100** | $435 | $382 | **$816** |
| 2025 | $525 | $1,617 | **$2,142** | $443 | $382 | **$825** |
| 2026 | $540 | $1,618 | **$2,158** | $456 | $382 | **$838** |
| 2027 | $555 | $1,618 | **$2,173** | $468 | $382 | **$851** |
| 2028 | $571 | $1,619 | **$2,190** | $482 | $383 | **$864** |
| 2029 | $587 | $1,619 | **$2,206** | $495 | $383 | **$878** |
| 2030 | $606 | $632 | **$1,238** | $505 | $9 | **$514** |
| 2031 | $623 | $632 | **$1,256** | $519 | $9 | **$529** |
| 2032 | $641 | $633 | **$1,274** | $534 | $10 | **$543** |
| 2033 | $659 | $634 | **$1,293** | $549 | $10 | **$559** |
| 2034 | $678 | $634 | **$1,312** | $564 | $10 | **$574** |
| 2035 | $697 | $21 | **$718** | $580 | $11 | **$591** |
| 2036 | $717 | $22 | **$738** | $596 | $11 | **$607** |
| 2037 | $737 | $22 | **$759** | $613 | $11 | **$624** |
| 2038 | $758 | $23 | **$781** | $630 | $12 | **$642** |
| 2039 | $779 | $24 | **$803** | $648 | $12 | **$660** |
| 2040 | $802 | $24 | **$826** | $666 | $12 | **$679** |

## Figure 7-1

**Number of Components?**

**Variable Operating Costs**

| Component Type | Component Name | Existing or Planned? | On-Line Year (for Planned) | Loss Rate | Ref. Year Power Costs ($/mg) | Ref. Year Chemical Costs ($/mg) | Ref. Year Purchase Costs ($/mg) | Ref. Year Other Costs ($/mg) | Ref. Year Revenues ($/mg) |
|---|---|---|---|---|---|---|---|---|---|
| Su | Diversion A | e | | 5% | $20 | | | | $10 |
| T | WTP A | e | | | $150 | $75 | | | |
| Su | GW #1 | p | 2015 | 20% | $100 | | | | |
| CP | Path Group 25 | e | | | $25 | | | | |
| CP | Path Group 50 | p | 2010 | | $50 | | | | |
| Su | Purchase B | p | 2024 | | | | $100 | | |
| T | WTP B | p | 2024 | | $100 | $50 | | | |
| | | | Annual Real Escalation Rates: | | 1.00% | 0.00% | 2.00% | 0.00% | 0.00% |

## Figure 7-2

**System Components:**
**On-Margin Probabilities**

| Year | Season | | Diversion A | WTP A | GW #1 | Path Group 25 | Path Group 50 | Purchase B | WTP B |
|---|---|---|---|---|---|---|---|---|---|
| | | *On-line dates:* | | | *2015* | | *2010* | *2024* | *2024* |
| | | *Type:* | *Su* | *T* | *Su* | *CP* | *CP* | *Su* | *T* |
| 2005 | Peak | | 70% | 100% | 0% | 20% | 0% | 0% | 0% |
| to 2009 | Off-Peak | | 90% | 100% | 0% | 10% | 0% | 0% | 0% |
| 2010 | Peak | | 75% | 100% | 0% | 20% | 10% | 0% | 0% |
| to 2014 | Off-Peak | | 90% | 100% | 0% | 10% | 10% | 0% | 0% |
| 2015 | Peak | | 50% | 100% | 10% | 30% | 10% | 0% | 0% |
| to 2019 | Off-Peak | | 70% | 100% | 10% | 10% | 10% | 0% | 0% |
| 2020 | Peak | | 50% | 100% | 15% | 30% | 10% | 0% | 0% |
| to 2024 | Off-Peak | | 80% | 100% | 10% | 10% | 10% | 0% | 0% |
| 2025 | Peak | | 45% | 90% | 15% | 40% | 10% | 10% | 10% |
| to 2029 | Off-Peak | | 85% | 100% | 10% | 10% | 10% | 0% | 0% |
| 2030 | Peak | | 45% | 80% | 20% | 50% | 10% | 20% | 20% |
| to 2034 | Off-Peak | | 90% | 100% | 10% | 10% | 10% | 0% | 0% |
| 2035 | Peak | | 45% | 80% | 20% | 50% | 10% | 20% | 20% |
| to 2039 | Off-Peak | | 90% | 100% | 10% | 10% | 10% | 0% | 0% |
| 2040 | Peak | | 45% | 80% | 20% | 50% | 10% | 20% | 20% |
| to 2044 | Off-Peak | | 90% | 100% | 10% | 10% | 10% | 0% | 0% |

## Figure 7-3

### Short-Run Avoided Costs
### ($/mg)

| Annual Short-Run Avoided Costs by Season<br>Nominal Dollars | | | Annual Short-Run Avoided Costs by Season<br>2005 Dollars | | |
|---|---|---|---|---|---|
| Year | Peak-Season | Off-Peak Season | Year | Peak-Season | Off-Peak Season |
| 2005 | $237.37 | $236.97 | 2005 | $237.37 | $236.97 |
| 2006 | $243.85 | $243.46 | 2006 | $239.07 | $238.69 |
| 2007 | $250.51 | $250.13 | 2007 | $240.78 | $240.42 |
| 2008 | $257.36 | $256.99 | 2008 | $242.51 | $242.17 |
| 2009 | $264.40 | $264.04 | 2009 | $244.26 | $243.94 |
| 2010 | $278.08 | $277.10 | 2010 | $251.86 | $250.97 |
| 2011 | $285.72 | $284.73 | 2011 | $253.71 | $252.83 |
| 2012 | $293.58 | $292.57 | 2012 | $255.58 | $254.70 |
| 2013 | $301.66 | $300.64 | 2013 | $257.46 | $256.59 |
| 2014 | $309.96 | $308.94 | 2014 | $259.36 | $258.50 |
| 2015 | $334.83 | $331.20 | 2015 | $274.67 | $271.70 |
| 2016 | $344.07 | $340.36 | 2016 | $276.72 | $273.74 |
| 2017 | $353.58 | $349.78 | 2017 | $278.79 | $275.80 |
| 2018 | $363.35 | $359.47 | 2018 | $280.88 | $277.88 |
| 2019 | $373.41 | $369.43 | 2019 | $282.99 | $279.98 |
| 2020 | $393.51 | $381.55 | 2020 | $292.38 | $283.50 |
| 2021 | $404.44 | $392.16 | 2021 | $294.61 | $285.67 |
| 2022 | $415.67 | $403.07 | 2022 | $296.86 | $287.86 |
| 2023 | $427.23 | $414.29 | 2023 | $299.13 | $290.07 |
| 2024 | $439.12 | $425.83 | 2024 | $301.42 | $292.30 |
| 2025 | $464.05 | $438.83 | 2025 | $312.29 | $295.32 |
| 2026 | $477.26 | $451.08 | 2026 | $314.89 | $297.61 |
| 2027 | $490.86 | $463.68 | 2027 | $317.51 | $299.93 |
| 2028 | $504.86 | $476.64 | 2028 | $320.16 | $302.27 |
| 2029 | $519.27 | $489.98 | 2029 | $322.84 | $304.63 |
| 2030 | $564.81 | $505.04 | 2030 | $344.27 | $307.84 |
| 2031 | $581.32 | $519.20 | 2031 | $347.39 | $310.26 |
| 2032 | $598.34 | $533.76 | 2032 | $350.54 | $312.71 |
| 2033 | $615.86 | $548.74 | 2033 | $353.74 | $315.18 |
| 2034 | $633.92 | $564.15 | 2034 | $356.97 | $317.68 |
| 2035 | $652.53 | $580.00 | 2035 | $360.24 | $320.20 |
| 2036 | $671.70 | $596.30 | 2036 | $363.55 | $322.75 |
| 2037 | $691.45 | $613.07 | 2037 | $366.91 | $325.32 |
| 2038 | $711.80 | $630.33 | 2038 | $370.30 | $327.92 |
| 2039 | $732.77 | $648.08 | 2039 | $373.73 | $330.54 |
| 2040 | $754.38 | $666.34 | 2040 | $377.21 | $333.19 |

## Figure 7-4

**Planned System Additions**

| Project Name | On-line Year | Capital Cost ($million) | Fixed O&M Cost ($/yr) | Defer/ Downsize? | Downsize Factor | Flow/ Volume? | Size Units | Size (Peak Season) |
|---|---|---|---|---|---|---|---|---|
| | | | | | If Downsize, then: | | | |
| GW # 1 | 2015 | $10 | | do | 0.8 | f | mgd | 10 |
| Reservoir North | 2010 | $100 | $100,000 | de | | | | |
| Pipeline North | 2010 | $20 | | de | | | | |
| WTB B | 2024 | $5 | $25,000 | do | 1 | f | mgd | 5 |
| Pipeline South | 2024 | $10 | | de | | | | |

Number of Projects?

Annual Real Escalation Rates: 1% 1%

Financing Term (yrs): 20

## Figure 7-5

**Seasonal Multipliers for Planned Additions**

| | Peak | | | | | Off-Peak | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GW # 1 | Reservoir North | Pipeline North | WTP B | Pipeline South | GW # 1 | Reservoir North | Pipeline North | WTP B | Pipeline South |
| | *2015* | *2010* | *2011* | *2024* | *2024* | *2015* | *2010* | *2011* | *2024* | *2024* |
| **2005** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **2010** | 1.00 | 1.00 | 0.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **2015** | 1.00 | 1.00 | 0.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **2020** | 1.00 | 1.00 | 0.70 | 1.00 | 1.00 | 0.00 | 0.60 | 0.00 | 0.00 | 0.00 |
| **2025** | 1.00 | 1.00 | 0.70 | 1.00 | 1.00 | 0.00 | 0.60 | 0.00 | 0.00 | 0.00 |
| **2030** | 1.00 | 1.00 | 0.70 | 1.00 | 1.00 | 0.00 | 0.70 | 0.00 | 0.00 | 0.00 |
| **2035** | 1.00 | 1.00 | 0.70 | 1.00 | 1.00 | 0.00 | 0.70 | 0.00 | 0.00 | 0.00 |
| **2040** | 1.00 | 1.00 | 0.70 | 1.00 | 1.00 | 0.00 | 0.70 | 0.00 | 0.00 | 0.00 |
| **2045** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

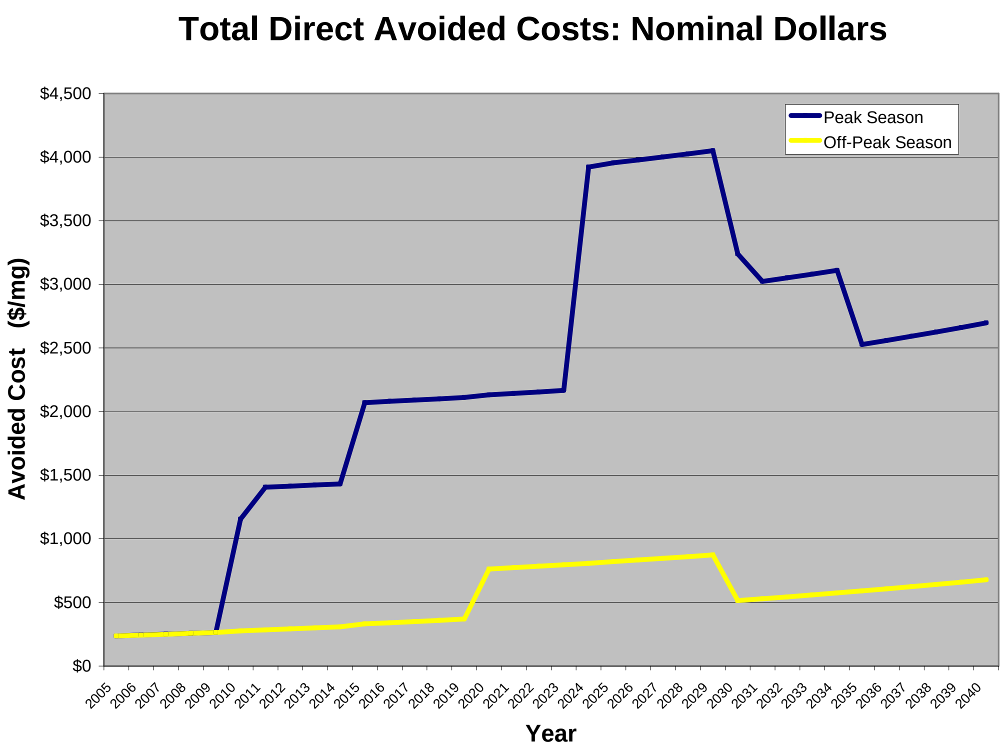
## Figure 7-6

| Total Long-Run Avoided Costs by Season<br>Nominal Dollars | | | | |
|---|---|---|---|---|
| | Peak-Season | | Off-Peak Season | |
| | ($ million/mgd) | ($/mg) | ($ million/mgd) | ($/mg) |
| | | | | |
| 2005 | $0.0000 | $0 | $0.0000 | $0 |
| 2006 | $0.0000 | $0 | $0.0000 | $0 |
| 2007 | $0.0000 | $0 | $0.0000 | $0 |
| 2008 | $0.0000 | $0 | $0.0000 | $0 |
| 2009 | $0.0000 | $0 | $0.0000 | $0 |
| 2010 | $0.1341 | $877 | $0.0000 | $0 |
| 2011 | $0.1714 | $1,121 | $0.0000 | $0 |
| 2012 | $0.1715 | $1,121 | $0.0000 | $0 |
| 2013 | $0.1715 | $1,121 | $0.0000 | $0 |
| 2014 | $0.1716 | $1,121 | $0.0000 | $0 |
| 2015 | $0.2656 | $1,736 | $0.0000 | $0 |
| 2016 | $0.2656 | $1,736 | $0.0000 | $0 |
| 2017 | $0.2657 | $1,736 | $0.0000 | $0 |
| 2018 | $0.2657 | $1,737 | $0.0000 | $0 |
| 2019 | $0.2658 | $1,737 | $0.0000 | $0 |
| 2020 | $0.2658 | $1,737 | $0.0808 | $381 |
| 2021 | $0.2659 | $1,738 | $0.0808 | $381 |
| 2022 | $0.2660 | $1,738 | $0.0809 | $381 |
| 2023 | $0.2660 | $1,739 | $0.0809 | $382 |
| 2024 | $0.5327 | $3,482 | $0.0809 | $382 |
| 2025 | $0.5341 | $3,491 | $0.0810 | $382 |
| 2026 | $0.5356 | $3,500 | $0.0810 | $382 |
| 2027 | $0.5371 | $3,510 | $0.0811 | $382 |
| 2028 | $0.5386 | $3,520 | $0.0811 | $383 |
| 2029 | $0.5402 | $3,530 | $0.0812 | $383 |
| 2030 | $0.4092 | $2,674 | $0.0019 | $9 |
| 2031 | $0.3736 | $2,442 | $0.0020 | $9 |
| 2032 | $0.3753 | $2,453 | $0.0020 | $10 |
| 2033 | $0.3771 | $2,465 | $0.0021 | $10 |
| 2034 | $0.3789 | $2,477 | $0.0022 | $10 |
| 2035 | $0.2869 | $1,875 | $0.0022 | $11 |
| 2036 | $0.2888 | $1,888 | $0.0023 | $11 |
| 2037 | $0.2908 | $1,901 | $0.0024 | $11 |
| 2038 | $0.2929 | $1,914 | $0.0024 | $12 |
| 2039 | $0.2950 | $1,928 | $0.0025 | $12 |
| 2040 | $0.2972 | $1,942 | $0.0026 | $12 |

## Figure 7-7

| Total Direct Utility Avoided Costs: Nominal Dollars ($/mg) | | | | | | |
|---|---|---|---|---|---|---|
| Year | Peak Season | | | Off-Peak Season | | |
| | Short-Run | Long-Run | **Total** | Short-Run | Long-Run | **Total** |
| 2005 | $237 | $0 | **$237** | $237 | $0 | **$237** |
| 2006 | $244 | $0 | **$244** | $243 | $0 | **$243** |
| 2007 | $251 | $0 | **$251** | $250 | $0 | **$250** |
| 2008 | $257 | $0 | **$257** | $257 | $0 | **$257** |
| 2009 | $264 | $0 | **$264** | $264 | $0 | **$264** |
| 2010 | $278 | $877 | **$1,155** | $277 | $0 | **$277** |
| 2011 | $286 | $1,121 | **$1,406** | $285 | $0 | **$285** |
| 2012 | $294 | $1,121 | **$1,414** | $293 | $0 | **$293** |
| 2013 | $302 | $1,121 | **$1,423** | $301 | $0 | **$301** |
| 2014 | $310 | $1,121 | **$1,431** | $309 | $0 | **$309** |
| 2015 | $335 | $1,736 | **$2,070** | $331 | $0 | **$331** |
| 2016 | $344 | $1,736 | **$2,080** | $340 | $0 | **$340** |
| 2017 | $354 | $1,736 | **$2,090** | $350 | $0 | **$350** |
| 2018 | $363 | $1,737 | **$2,100** | $359 | $0 | **$359** |
| 2019 | $373 | $1,737 | **$2,110** | $369 | $0 | **$369** |
| 2020 | $394 | $1,737 | **$2,131** | $382 | $381 | **$763** |
| 2021 | $404 | $1,738 | **$2,142** | $392 | $381 | **$773** |
| 2022 | $416 | $1,738 | **$2,154** | $403 | $381 | **$785** |
| 2023 | $427 | $1,739 | **$2,166** | $414 | $382 | **$796** |
| 2024 | $439 | $3,482 | **$3,921** | $426 | $382 | **$808** |
| 2025 | $464 | $3,491 | **$3,955** | $439 | $382 | **$821** |
| 2026 | $477 | $3,500 | **$3,978** | $451 | $382 | **$833** |
| 2027 | $491 | $3,510 | **$4,001** | $464 | $382 | **$846** |
| 2028 | $505 | $3,520 | **$4,025** | $477 | $383 | **$859** |
| 2029 | $519 | $3,530 | **$4,050** | $490 | $383 | **$873** |
| 2030 | $565 | $2,674 | **$3,239** | $505 | $9 | **$514** |
| 2031 | $581 | $2,442 | **$3,023** | $519 | $9 | **$529** |
| 2032 | $598 | $2,453 | **$3,051** | $534 | $10 | **$543** |
| 2033 | $616 | $2,465 | **$3,080** | $549 | $10 | **$559** |
| 2034 | $634 | $2,477 | **$3,110** | $564 | $10 | **$574** |
| 2035 | $653 | $1,875 | **$2,528** | $580 | $11 | **$591** |
| 2036 | $672 | $1,888 | **$2,559** | $596 | $11 | **$607** |
| 2037 | $691 | $1,901 | **$2,592** | $613 | $11 | **$624** |
| 2038 | $712 | $1,914 | **$2,626** | $630 | $12 | **$642** |
| 2039 | $733 | $1,928 | **$2,661** | $648 | $12 | **$660** |
| 2040 | $754 | $1,942 | **$2,697** | $666 | $12 | **$679** |

# Figure 7-8


Total Direct Avoided Costs: Nominal Dollars
Avoided Cost ($/mg)
$4,500
$4,000
$3,500
$3,000
$2,500
$2,000
$1,500
$1,000
$500
$0
Peak Season
Off-Peak Season
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
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2040
Year

# APPENDIX C: FAQ – DIRECT UTILITY AVOIDED COST MODEL

## COMMON ASSUMPTIONS

Q. What do I use for a planning horizon?

A. The planning horizon is the period over which the model will compute avoided costs. It would be prudent to use something consistent with utility planning. The planning horizon used in the utilities' Urban Water Management Plan (UWMP) would be one default.

Q. What is the "real" discount rate?

A. The real discount rate is the discount rate net of inflation. All costs in the model are expressed in real (net of inflation)terms. Most utility financial analyses that track cash flow tend to be denominated in nominal costs and use nominal discount rates. The model provides a converter that the user may use to translate nominal into real discount rates.

Q. Do I have to use the real discount rate converter?

A. No, its use is entirely optional. The user must, however, enter the discount rate in real terms.

Q. How do the escalation rates in the costs of, variable operating costs (e.g. power or chemicals) relate to the general inflation rate?

A. The escalation of production costs are expressed in real terms. Thus, they are net of the general inflation rate.

## DEMANDS

Q. What type of demand data should be entered into the *Demands* sheet?

A. The Demand data must be based on metered consumption. Production estimates are usually higher than consumption due to system losses. System Losses are handled separately. Therefore, production data would be inappropriate for this sheet.

**VARIABLE OP. COSTS**

Q. What if a supply source has a minimum operating level (i.e. it can only be cut back to a certain point and not beyond that due, for example, to regulatory or technical constraints)?
A. This type of condition would be reflected in the on-marginal probabilities of this source. They would be lower than they otherwise would have been.

Q. The model has two types of system loss inputs, a 'Lost and Unaccounted for Water' input on the Common Assumptions Sheet, and component-specific loss factors on the Variable Operating Costs sheet. How do they relate?
A. The user can use either or both types of loss inputs. The system-wide loss factor is applied to all supply and storage components to increase their avoided costs. The component-specific factors are only applied to the particular component, and thereby give the user more flexibility to tailor the model's consideration of losses. The two types of factors are cumulative, i.e. the model will make both adjustments, so the user should take care not to double count losses.

Q. What is a "conveyance path"?
A. A conveyance path is a way to move water from source to meter. For purposes of estimating short-run avoided costs, we are concerned with conveyance paths which have pumping costs. The user is asked to group conveyance paths by approximate pumping costs so the model can include avoided pumping costs in the overall short-run avoided cost calculation.
Q. How should variable treatment costs be handled?
A. They should be either accounted for as costs associated with an identified treatment plant component OR as part of the costs of conveyance path group(s), but NOT BOTH.

**ON MARGIN PROBABILITIES**

Q. What does a 100 percent on-margin probability for a system component in a season mean?

A. It means that, in that season, each and every unit of demand reduction will reduce the production or throughput of that component by one loss-adjusted unit. An on-margin probability of less than 100% means that, some of the time, the production or throughput of the component will not be affected by demand reductions. The on-margin probability is *not* the same as the probability that a component will be used. For example, a supply that is base loaded may be running 100% of the time, but may seldom or never be subject to cut back in response to conservation savings. The on-margin probability for such a supply will be close to zero.

Q. I am seeing pink boxes that say things like "Category > 100%" or "Nonzero probability prior to online date". What are these?

A. These are warning signs based on logic checks. Within each category, the on-margin probabilities cannot add to more than one. (Categories are (1) Supply and storage; (2) Treatment; (3) Conveyance paths.) The solution involves adjusting the individual probabilities so that they sum to one or less within each category.) Similarly, it is not logically possible to have a non-zero probability of being on margin before a component comes on line.

Q. Is it possible to have on-margin probabilities that sum across a category to something less than 100%?

A. Yes. If the user does not include on the Variable Operating Costs sheet those system components with zero variable operating costs, and those components have some likelihood of being 'on the margin', the on-margin probabilities for the remaining components in that category will add to less than 100%.

Q. Why would I want to use the "conditions" to determine on-margin probabilities?

A. It may be easier for the utility to estimate the on-margin probabilities under particular hydrologic, weather, or other conditions. For example, state agencies sometimes use three “water year types” to depict hydrologic uncertainty, dry years, normal years, and wet years. The user, if so desired, could separately enter the probabilities for each of these year types. Based on these entries and user-entered likelihoods of occurrence for each of these year types, the model would then compute a composite set of probabilities. The three sheets for calculating a weighted average on-margin probability are *entirely* optional. They may be used when the defining inputs are more sensible when attached to separate conditions.

**PLANNED ADDITIONS**

Q. Do all of the planned components in the short-run calculations have to appear in the long run calculations?

A. No. Some planned components which have avoidable variable operating costs may not have any avoidable capital costs (e.g. a water purchase). Conversely, some planned components that have avoidable capital costs may not have avoidable variable operating costs (e.g. a dam raise). Many other planned components will appear in both places.

Q. When do I use deferral and when do I use downsizing?

A. Projects that are driven by demand growth can, in general, be deferred by a reduction in that growth. It could be the case, for institutional or regulatory reasons, that the timing of some projects is not affected by reductions in demand growth. These projects, however, may still have some potential long run avoided costs if their size can be reduced. For each project on the Planned Additions sheet, the user must determine which option makes more sense.

**SEASONAL MULTIPLIERS**

Q. What is a seasonal multiplier?

A. Seasonal multipliers express the degree to which the costs associated with each planned addition are avoided as a result of demand reductions in the peak as well as the off-peak season. An entry of 1.0 means that each unit of demand reduction in that season results in the total annualized cost being avoided; a zero entry means no costs are avoided. Since peak-season demand often drives system additions, in many cases the peak-season multipliers will be 1, and the off-peak-season multipliers will be zero.

Q. Why would I have a probability other than zero or one?
A. If the water utility has seasonal storage, some of the water conserved in the off-peak season can be shifted to reduce peak demand; in this case a nonzero seasonal multiplier can be used to capture the effect of this “seasonal shift.” This is an example of where a system simulation model would be useful to better reflect a more complicated reality.

Q. How could the peak season seasonal multiplier be less than one.
A. While it typically would not, one example where it might is a system expansion that only serves a subset of the utility’s service area. The burden is on the user to explain why particular values make sense.

## TOTAL DIRECT AVOIDED COSTS

Q. How would I use the total direct avoided costs in a cost benefit analysis of a conservation program?
A. The avoided cost per unit conserved in a given year/season is multiplied by the number of units conserved in that year/season. The resulting product is the estimate of utility benefit that results from the conservation program. These benefits are then compared to the utility’s program costs.

Q. Are the direct utility avoided costs specific to any conservation program or BMP?
A. No. The estimates of seasonal avoided cost do not care which BMP or which conservation program produces a particular unit of reduced demand. The total benefits of conservation programs in each year/season will vary depending on how much the program saves in that year/season.

## NON-WATER UTILITY AVOIDED COSTS

Q. Why is this sheet here?

A. The sheet on Non-Water Utility Avoided Costs is a convenient place to keep track of potential avoided costs outside of the water utility. This is done for two reasons. First it forms a good way initiating cost-sharing discussions with other institutional beneficiaries of water conservation programs. Second, it ensures that perspectives outside of a water utility have a place at the table. The user should note that there is an increased risk for double counting when keeping track of multiple institutional perspectives.